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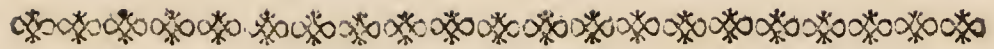
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EXPERIMENTAL INQUIRIES  
INTO THE  
LYMPHATIC SYSTEM.







Experimental Inquiries :  
PART THE SECOND.  
CONTAINING  
A DESCRIPTION  
OF THE  
LYMPHATIC SYSTEM

In the HUMAN SUBJECT,  
And in OTHER ANIMALS.

ILLUSTRATED WITH PLATES.

Together with Observations on the LYMPH,  
and the Changes which it undergoes  
in some Diseases.

---

By WILLIAM HEWSON, F. R. S.  
AND TEACHER OF ANATOMY.

---

*Atque in anatomia corporum organicorum (qualia sunt  
hominis & animalium) opera sane recte & utiliter insumi-  
tur ; & videtur res subtilis & scrutinium naturæ bonum.*

Lord BACON.

---

L O N D O N :

Printed for J. JOHNSON, No. 72, St. Paul's Church Yard.  
M.DCC.LXXIV.



T O

BENJAMIN FRANKLIN,

*L. L. D. F. R. S.*

*S I R,*

**P**ERMIT me to dedicate this Essay to you, as a Tribute to your Genius which has deservedly obtained you the first Place amongst Philosophers ; and as a mark of Gratitude, for the many Acts of Friendship with which you have honoured,

Sir,

Your much obliged,

And most obedient

Humble Servant,

WILLIAM HEWSON.





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## P R E F A C E.

**T**HE science of anatomy has now been so long and so successfully cultivated, that most parts of the human body have been both carefully described and accurately delineated; but the vessels which are the subjects of this essay, having only of late been made known to anatomists, and not being easily traced by dissection, have not been completely described, nor have they ever been delineated. The following, therefore, is an attempt, in some measure, to supply these deficiencies; and the author flatters himself, that when it is considered how great a share those vessels have in the composition of our body, and how im-

portant the offices are which they perform, that this small addition to the stock of Anatomical Science will not be unacceptable, either to the practitioners of the healing art, or to the philosophical inquirers into the works of nature.

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22	1	<i>for tibalis read tibialis</i>
<i>ibid.</i>	6	<i>for shin read skin</i>
23	4	<i>for is read in</i>
29	3	<i>for extremeties read extremities</i>
108	17	<i>for peritoneum read peritonæum</i>
114		<i>for abcefs read abscess</i>
157	7	<i>after through add the</i>

## To the Book-Binder.

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Plate III.	— — 230, bound in at the
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Plate V.	— — 236, and upright
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OF THE  
LYMPHATIC SYSTEM.

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C H A P. I.

*A short History of the Discoveries made in  
the Lymphatic System.*

SINCE the days of *Asellius*, of *Rudbeck* and of *Bartholin*, who by their successful inquiries first proved the existence of those vessels in the human body which are now called the Lymphatic System, no part of anatomy has more engaged the attention of its professors: partly from its being the largest field that has been lately opened for  
B their



their cultivation, and partly from their being so thoroughly persuaded of its great importance.

*Asellius* in the year 1622, reaped the first laurels in this field, by his discovery of those vessels on the mesentery, which, from their carrying a milk-like fluid, he denominated lacteals†. This discovery being made by opening a living dog, anatomists were thence encouraged to make experiments on living animals; and *Pecquet*, on opening a dog in the year 1651, found a white fluid mixed with the blood in the right auricle of the heart. Suspecting this fluid to be chyle, he endeavoured to determine how it got from the lacteals into the heart; this he found was by means of the *Ductus Thoracicus*, which he traced from the lacteals to the subclavian vein\*, and thus

† *Asellius de Lact.*

\* *Pecquet Exp. Nova Anat. fig. 2d, in Hemsterhuis, Melle Aurea.*

he clearly proved the existence of that duct which we now consider as the trunk of the system. Just before his time the lacteals had been supposed to terminate in the liver, conformably to the idea which the physiologists of that period had adopted about the use of this organ, which, from the authority of the older anatomists, they believed was the *Viscus Hæmatopoeticum*, or received the chyle from the intestines to convert it into blood.

Next, *Rudbeck*, Anno. 1651, † *Dr. Jolyffe* ‡, and *Thomas Bartholin*, about the year 1652 ||, discovered the other parts of this system, which from their carrying a transparent and colourless fluid, are called the lymphatic vessels. And thus there was proved to exist in an animal

† Ol. Rudb. Exercit. Anat. Cap. 1, in Hemsterhuis *Messe Aurea*.

‡ Glisson de Hepate, cap. xxxi.

§ Barthol. de Lacteis Thoracis, in Hemsterhuis *Messe Aurea*.

#### 4      *Of the Lymphatic System.*

body a system of small vessels carrying fluids very different from the blood, and opening into the sanguiferous vessels at the left subclavian vein.

To *Asellius*, *Pecquet*, *Rudbeck*, *Jolyffe* and *Bartolin*, we are therefore indebted for the discovery of the different parts of this system; not but that some of these vessels had been seen and mentioned by their predecessors, but it was in too cursory a manner to give them any title to the discovery\*.

After this period *Nuck* added to our knowledge of this system by his injections of the lymphatic glands †, and

\* Thus the lacteals had been seen in kids by *Erasistratus*, who calls them arteries, as we are informed by *Galen*. See *Galen* oper. Tom. 1, p. 61, edit. apud Junt.

The Thoracic Duct had been seen by *Eustachius*, who speaks of it as a vein of a particular kind. See *Eustachius* de Vena sine Pari.

† See his *Adenographia*.

*Ruyfch*



*Ruysch* by his description of the valves of the lymphatic vessels,\* and *Dr. Meckel* by his accurate account of the whole system, and by tracing those vessels in many parts where they had not before been described †.

Besides these authors, *Dr. Hunter* and *Dr. Monro* have called the attention of the public to this part of anatomy, in their controversy concerning the discovery of the office of the lymphatics.

When the lymphatic vessels were first seen and traced into the thoracic duct, it was natural for anatomists to suspect, that as the lacteals opened into the intestines to absorb, the lymphatic vessels, (which are branches of the same system) might possibly do the same office with respect to other parts of the body; and accordingly *Dr. Glisson*, who wrote in

\* In his *Delucidatio Valvularum*.

† *Epistola ad Hallerum*.

1654 (that is, the very year after *Bartholine* published on the lymphatic vessels) supposes these vessels arose from cavities, and that their use was to absorb; and *Frederic Hoffman* has very explicitly laid down the doctrine of the lymphatic vessels being a system of absorbents\*. But anatomists in general have been of a contrary opinion; for from experiments, particularly such as were made by injections, they have been persuaded that the lymphatic vessels did not arise from cavities, and did not absorb, but merely were continued from small arteries. The doctrine therefore that the lymphatics like the lacteals, were absorbents, as had been suggested by *Glisson* and by *Hoffman*, has been revived by Dr. *Hunter* and Dr. *Monro*, who have controverted the experiments of their predecessors in anatomy, and have endeavoured to prove that the

\* See below, chap. 10.



lymphatic vessels are not continued from arteries, but are absorbents.

To this doctrine however many and strong objections have been started, particularly by the learned M. *de Haller*\*, and it has been found, that before the doctrine of the lymphatics being a system of absorbents can be established on a solid foundation, it must first be determined, whether other animals, besides man and quadrupeds, have or have not this system. I have been so fortunate as to prove the affirmative of this question, by discovering the Lymphatic System in birds, fish, and amphibious animals†, and in consequence of these discoveries I have also arrived at the knowledge of considerable varieties in the composition of those vessels through the various classes of animals; by comparing this know-

\* Elem. Phys. lib. xxiv, sect. 2, 3.

† Accounts of which have already been published in the Phil. Transactions, vol. 58 and 59.

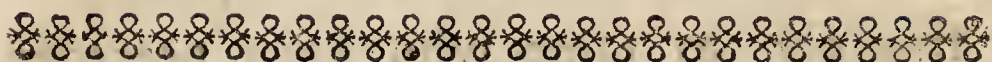
I pledge with some facts that I have lately observed concerning the blood, I have thence been led to ascertain the use of the lymphatic glands, the thymus, and the spleen; which have so long been considered as the *opprobria* of anatomists.

These last observations I propose making the subject of a future publication\*; but in order to prepare the reader for it, I have thought it necessary to lay before him a description and comparison of the lymphatic vessels in different animals. And that this may be the more worthy his attention, I have not only traced those vessels in most parts of the human body as *Dr. Meckel* has done, but I have observed some circumstances which had escaped his notice; and I have illustrated the description with plates, the

\* An abstract of these discoveries, though an imperfect one, has been published in the medical commentaries of Edinburgh, No. 1st, but without my concurrence.

necessity of which has appeared so strongly to some who have preceded me in this subject, particularly to Mess. *Monro*, *Meckel* and *Hunter*, that they have each promised to supply the deficiency, but none of them having yet done it, I have undertaken the task myself, that I may be able to refer the reader to the facts from which my conclusions are made.





## C H A P II.

*A general Account of the Lymphatic System.*

**T**HE lymphatic system consists of the lacteals, the lymphatic vessels, their common trunk the thoracic duct, and the glands called conglobate,

The lacteals begin from the intestinal tube, and can readily be seen in a dog or other quadruped that is killed two or three hours after eating, when they appear filled with a white chyle. The experiment succeeds best when the dog is fed with milk: but they do not always convey a white fluid, for, even in the dog, if opened long after a meal, they are found distended with a liquor that is transparent and colourless

colourless like the lymph; and in birds I have never found the chyle white but always transparent and limpid; these vessels therefore might, with as much propriety, be called the lymphatics of the intestines.

The lymphatic vessels are small pellucid tubes that have now been discovered in most parts of the human body; the fluid they contain is generally as colourless as water, a circumstance which procured them at first the name of *Ductus Aquosi*\*, and afterwards that of *Vasa Lymphatica*†. The course of the lymph, like that of the chyle, is from the extreme parts of the body towards the centre, and the lymphatic vessels commonly lie close to the large blood vessels. If therefore a ligature be made round the large blood vessels of the extremities of a living animal, or of one

\* See Rudbeck, l, c.

† See Bartholin, l, c.



just dead, that ligature, by embracing the lymphatics, will stop the course of the lymph, which by distending the vessels will make them visible below the ligature.

All the lacteals and most of the lymphatic vessels open into the thoracic duct, which lies upon the spine and runs up towards the neck of the animal, where it commonly opens into the angle between the jugular and subclavian veins of the left side; and thus both the chyle and lymph are mixed with the blood. If therefore the thoracic duct be tied instantly after killing an animal, not only the lacteals, but also the lymphatics in the abdomen and lower extremities become distended with their natural fluids; the course of those fluids being stopt by the ligature.

The lacteals, the lymphatics, and the thoracic duct, all agree in having their  
coats

coats more thin, and more pellucid than those of the blood vessels. But although their coats are so thin they are very strong, as we daily see on injecting them with mercury, since they resist a column of that fluid, whose weight would make it burst through blood vessels, the coats of which are many times thicker than those of the lymphatic system.

The thinness of the coats prevents our dividing them from one another, and thereby ascertaining their number as we do those of the blood vessels. But as the blood vessels have a dense internal coat to prevent transudation, we have reason to believe the lymphatics have the same. And as the blood vessels have a muscular coat, which assists in the circulation\*, so may the

\* The existence of the muscular coat of the blood vessels has been rendered probable by Dr. Verschuur's experiments, wherein these vessels were

lymphatics, as is rendered probable from what Dr. *Haller* says of his having found them irritable in his experiments

found to be irritable, and also by the following circumstance which I observed in dissecting an ass. The arteries of this, like those of other animals, have a strong elastic coat, which coat after distention contracts them again to a certain degree; but this contraction never goes so far as to shut up the cavity of the artery, and as it acts equally in the dead as in the living body, large arteries are therefore always found with considerable cavities. But in this ass, which I bled to death, the arteries contracted more than their elastic coats were capable of doing; for those of the kidneys were without a cavity and resembled a cord; and that this contraction was muscular appeared upon distending them again, in which case they stood open as they commonly do in dead bodies. This fact will help us to explain why the arteries appear empty in dead bodies; which may be owing to their muscular fibres having (before death) contracted to the degree seen in this animal, by which means all the blood was driven into the veins; but these muscular fibres ceasing to act after death, the elastic fibres



ments†, and also from what is observed on seeing them in living animals distended with their lymph, in which case they appear of a considerable size; but upon emptying them of their contents, they contract so much as not to be easily distinguished. This is an experiment which I have frequently made in the trunk of the lacteals in a goose and on the lymphatic vessel on its neck, both of which when distended with their natural fluids are as large as a crow quill; but on emptying them in the living animal, I have seen them contract so much that it was with the greatest difficulty

bres overcome that contraction, and expand the arteries which therefore appear empty.

Since writing the above, I have dissected a still-born child which was defective in many parts of the body, and in particular in having no heart. In this child the circulation had been carried on merely by an artery and a vein, whose coats therefore probably were muscular.

† Sur le Mouv. du Sang, Ex. 295, 298.

I could



I could distinguish them from the fibres†.

The coats of lymphatic vessels have, in common with all other parts of the body, arteries and veins for their nourishment; this is rendered probable by their being susceptible of inflammation, for they are frequently found in the form of a cord, painful to the touch, and extending from an ulcer to the next lymphatic gland; instances of which are mentioned below\*. These painful swellings of lymphatic vessels likewise shew that their coats have sensibility, and therefore that they have nerves as well as arteries and veins.

† See also Haller, *El. Phys. Lib. 2, sect. 3. §iii.*

The celebrated Nuck thought he could separate the coats of the lymphatics, *Adenograph, cap. iii.*

\* Chap. 13.

The

The lymphatic system in most animals, but particularly in man and quadrupeds, is full of valves. These valves have been painted by the celebrated *Nuck*, *Ruyfch* and others, and are much more frequent than in the common veins, and thence these lymphatics have sometimes been distinguished by the name of valvular lymphatic vessels. Those valves are generally two in number, are of a semilunar shape, and the one is sometimes much larger than the other. In most parts of the body these valves are so numerous, that there are three or four pair in an inch of space, but sometimes there is no more than one pair. They are less numerous in the thoracic duct than in the branches of the system; thence it might be supposed, that in proportion as we go from the trunk to the branches, we should find them thicker set: but this is not always true, for I have observed them more numerous in the lymphatic ves-

sels of the thigh, than on those of the leg. When the vessels are distended with lymph they appear larger where the valves are; which sometimes gives a lymphatic vessel an appearance of being made of a chain of vesicles; as such they are represented by some authors\*: But it is an appearance that very seldom occurs; the reader will not observe it in any of the plates which are here laid before him.

Lastly the lymphatic system, in different parts of its course, has the glands called conglobate, or lymphatic. These glands are so placed that the vessels come in on one side, and pass out on the other, in their way to the thoracic duct. Before the discovery of the lymphatic vessels in birds, fish and turtle, some anatomists have considered these glands as so essentially necessary to the lymphatic system, that they have gene-

• See Nuck's *Adenographia*.



rally set about discovering the vessels by first looking for those glands ; and wherever they found glands, they pronounced that there must be vessels, and when no glands could be seen, they thought it as certain a proof of there being no vessels. But as we know they are wanting in some animals, I shall not take notice of their structure and use in this chapter ; but shall speak of them in a future publication, where I shall treat of the spleen and thymus, with which they are connected in their office.



## C H A P. III.

*A particular Description of the Lymphatic System in the Human Body.*

**I**T has already been observed, that the lymphatic system, besides the glands, is divided into three parts, viz. The lacteals, the lymphatic vessels, and the thoracic duct. That the lacteals belong to the intestinal tube, whilst the lymphatic vessels belong to all the other parts of the body, and that the thoracic duct is the common trunk which receives both the lacteals and the lymphatics. I shall next proceed to give a particular description of each of these vessels, and shall begin with the lymphatics of the lower extremities.

The lymphatic vessels of the lower extremities may be divided into two sets, viz. a superficial, and a deep seated.

The

The superficial set of lymphatics consists of a considerable number of vessels that lie between the skin and the muscles, and belong to the surface of the body, or the skin, and to the cellular membrane which lies immediately under it. Of these there are two large branches that can be readily enough discovered in the limbs of dropfical subjects. One of which runs upon the top of the foot as is represented *Plate 1.* (a) another can generally be found just under the inner ankle. I have introduced pipes into both of them, and have thereby filled them the whole length of the lower extremity, as is seen in *Plate 1.*

The lymphatic (a) \* which belongs to the toes, runs up on the outside of  
C 3 the

\* The small letters refer to the outlines; the capitals to the figure itself, which therefore the reader is requested to examine after viewing the outlines



the tendon of the *tibialis anticus* (I), till it has got above the ankle ; and it divides at (b) and again at (c,c,c) forming a *plexus*, which runs over the shin bone, (H) and ascends in the cellular membrane immediately under the skin between that bone and the internal belly of the *gastrocnemius* (G) to the inside of the knee (F) where in this figure it disappears, but may be seen in *Plate 2*. This plexus, having passed the inside of the knee, appears upon the thigh immediately under the skin, and over all the muscles, as is seen in *Plate 1*. (e), from which it passes to the groin, where these vessels enter the lymphatic glands.

The lymphatic glands of the groin are six, seven, or eight in number ; of these some lie in the very angle between the thigh and the abdomen, and others  
lie

lie a few inches down, on the fore part of the thigh. The lymphatic vessels, above described, enter the lowermost of these glands, which ~~is~~<sup>is</sup> the subject of this plate are four in number, viz. (f,f, g,g): one branch however avoids these glands as at (h), which afterwards bends over at (i) to the gland (k); from which go vessels to the other lymphatic glands (l,l) that lie in the angle between the thigh and the abdomen. It is into these upper glands alone that the lymphatic vessels of the genitals enter, so that the venereal bubo which arises in consequence of an absorption of matter from these organs, is always seated in those upper glands, and the lower glands (f,f, g,g,) are never affected, except by the regurgitation of the matter, or from their vicinity to the glands first diseased, which very seldom happens. And, as it is the upper glands that are affected by the absorption of matter from the genitals,



24      *Of the Lymphatic System.*

so it is the lower which are commonly first affected from the absorption of the acrid matter of an ulcer, diseased joint, carious bone, (in the parts below these glands,) a circumstance that may assist us in the *diagnosis* of those two kinds of buboes: Remembering however that this rule may be liable to an exception from one of the lymphatic vessels passing the lower glands, and only entering the upper, as is seen at (h) in the same plate.

The lymphatic vessels of the genitals having joined those of the thigh, a network is formed, which enters the abdomen under the edge of the tendon of the external oblique muscle, called pouparts ligament, one of these vessels is seen in *Plate 3. (b,b.)* This *plexus* on the inside of pouparts ligament consists of many branches, some of which embrace the iliac artery, of which one is seen in *Plate 3. at (c,c.)* but the greatest



est number of them pass up in the inside of the artery, as is seen at (m n) in *Plate 1.* and at (c,c.) *Plate 3.*

These superficial lymphatics, small as they are, \* probably are the trunks of those vessels which absorb from the skin and the cellular membrane immediately under it; and as no considerable branches can be distinguished on the outside of the leg or thigh, it is probable that all the lymphatic vessels of those parts bend towards the inside, and open into the trunks that are here represented.

Upon these vessels, from the foot to the groin, there is commonly not one

\* With respect to the size of these lymphatics, it is necessary to observe, that although the limb is represented in this plate about a third of the natural size, yet the artist could not express the lymphatic vessels to the same scale, so that all of them appear larger than they ought to be in proportion to the magnitude of the limb.

lymphatic

lymphatic gland. But this rule has likewise some exceptions, for, even at the lower part of the leg, there is a very small one in the subject from which this plate was taken; it is represented at (d) *Plate 1*: and in another subject I saw a small lymphatic gland near (e), but these, I believe, seldom occur; however they lead to this conclusion, that the lymphatic glands even in the human body, are in number and situation a little different in different subjects.

Besides these superficial lymphatic vessels which lie above all the muscles, or in the cellular membrane under the skin, there is a set deeper seated that lie amongst the muscles and accompany the crural artery of these the principal trunk can be discovered by cutting down to the posterior tibial artery, near the inner ankle; I have introduced a pipe  
into



into it at this part and have injected it in several subjects, one of which is represented *Plate 2.*

From the inner ankle at (a,) this vessel passes up along with the posterior tibial artery, being hid amongst the muscles on the back part of the *tibia*. About the middle of the leg it enters a small gland at (c), and as I have seen this gland in several subjects, I suspect it will be commonly found. Having passed through this gland the lymphatic runs up to the back part of the ham, still lying close to the artery, and in the ham it passes through three glands, *viz.* (f, g, h). I have seen a subject in which I could find only two glands, so that I suspect the number varies. Hitherto this lymphatic has been a single trunk; but after it has passed these glands it commonly divides into two or three branches, which still accompany the crural artery, and pass with it through



through the perforation in the *triceps* muscle. This muscle is divided in the preparation from which this figure was taken, in order to give a better view of the lymphatics; and the cut ends of the muscle appear at (F, F), though not very distinctly, from their being shrunk by drying. The lymphatic vessels having perforated the *triceps*, pass up with the artery, as is seen at (k, l.) and enter a gland (m) which is deeper seated than those which appear in the groin in *Plate I*; from this gland they pass into the superficial glands, represented in *Plate I* at (f, f, g, g) where the lymph of the deep seated, and of the superficial lymphatics is mixed, and is conveyed into the body by the vessels seen just above in the same plate. At this part likewise the lymph from the genitals is mixed with that brought by the two sets of lymphatics from the lower extremities; and the whole enters the abdomen by the  
*plexus*

*plexus* of vessels represented *Plate 1*, at (m), and a part of it at *Plate 3 (c)*.

The lymphatics of the lower extremities having now reached the trunk of the body, and having passed under *pouparts* ligament, appear upon the sides of the *ossa pubis* near the pelvis at (c, c) *Plate 3*. A part of them passes up along with the *illiac* artery upon the brim of the *pelvis*, and another part dips down into the cavity of the *pelvis*, and joins the internal *illiac* artery near the *sciatic* notch. At this place they are joined by the lymphatics from the contents of the *pelvis*, particularly from the bladder and the *vesiculæ seminales* in the male, and from the *uterus* in the female, and there are likewise a few branches which pass through the *sciatic* notch from the neighbourhood of the *glutei* muscles. The lymphatic vessels of the *uterus*, like its blood vessels, are much enlarged, and therefore easily



easily distinguished, in the pregnant state of that organ. At this part, where so many lymphatic vessels join, there is commonly one or two glands.

Besides those lymphatic vessels which dip down into the cavity of the *pelvis* on the inside of the external illiac artery at (*c, c*) Plate 3\*, there are others which keep on the outside of that artery upon the *psoas* muscle, some of which are seen on the left side in the same plate at (*d;*) of these one part passes up to the loins at (*b,*) and goes under the *Aorta* in different branches, getting from the left side to the right, and joining the thoracic duct. Another part passes under the illiac arteries and appears upon the *os sacrum* at (*f*), making a beautiful network, join-

\* The letters of reference are very small on this plate, and the reader it is hoped will excuse the trouble it may give him to observe them.



ing the lymphatics of the right side, and passing under the right iliac artery, to form the network (*g*) upon the upper part of the right *psoas* muscle. In different parts of this course from poupart's ligament to the loins, and also in the loins themselves there are, in most subjects, many lymphatic glands; none of which were filled in the subject from which this plate was made.

The lymphatic vessels of the right side, joined by some from the left, having now reached the right lumbar region, appear there in the form of a *plexus* of large vessels, and pass through several glands, which in this subject occupied the spaces (*i, i, i*), but not being injected with mercury are not represented; at this part likewise they receive large branches, under the aorta, from the *plexus* on the left side of the loins, as is mentioned before; and having at last got up as high as the second lumbar *vertebra*, they all join

join, and form a single trunk called the thoracic duct, which is seen at (*m*) Plate 3. At this part they are likewise joined by the lacteals, which I shall next describe.

The lacteal vessels, so called from their commonly conveying a fluid that is of the colour of milk, begin from the inner surface of the intestines, where they have patulous orifices destined to imbibe the nutritious fluid or chyle : From the cavity of the intestines these vessels pass obliquely through their coats, uniting as they go so as to form larger branches. These branches run on the outside of the gut to get to that part which is next the mesentery; and, whilst they are yet upon the gut, they are sometimes of a size sufficient to admit a small pipe, so that I have injected them with mercury even in the human subject.

From



From the intestines they run along the mesentery and *mesocolon*, towards the spine; and in their way they pass through the conglobate or mesenteric glands, which in the human subject are very numerous. These glands divide the lacteals into two regions, for from the intestines to the glands these vessels are called *lacteæ primi generis*, and from the glands to the thoracic duct, *lacteæ secundi generis*.

The lacteals of the small intestines, as they run upon the mesentery, commonly accompany the superior mesenteric artery, and unite, as they go on, into larger branches, so that by the time they have reached the root of the mesentery, they are of a considerable size, as may be seen in *Plate 3.* at *(k)*: From the mesenteric artery they pass down by the sides of the *aorta*, and open into the thoracic duct, as is seen at *(m)*. Whilst

D

the



the lacteals, or rather the lymphatics of the large intestines, accompany the inferior mesenteric artery, and open into the large lymphatic vessels near its root.\*

Into the thoracic duct at (*m*), likewise enters the lymph of the other *viscera* contained in the *abdomen*. This lymph is brought by a number of vessels; a *plexus* of which may be traced from each kidney, lying principally behind the emulgent artery, and opening into the large lymphatic vessels near the *aorta*: with these likewise go the lymphatics of the *glandulæ renales*, or renal *capsulæ*, as they are called.

The lymphatic vessels of the spleen pass from the concave side of that *viscus*, along with the splenic artery in the sinuosity of the *pancreas*, by the

\* The lymphatic vessels arise even from the *rectum*, as can be seen in quadrupeds that are opened immediately after death; or in fish when a coloured injection is thrown into their lymphatic system.

lym-

lymphatic vessels of which they probably are joined.

The stomach has two sets of lymphatic vessels, the one running upon its lesser, and the other upon its greater curvature; that which belongs to its lesser curvature accompanies the coronary artery, and passes through some lymphatic glands that lie by its sides. The other set of lymphatic vessels passes from the great curvature of the stomach, through some lymphatic glands that lie close to the *arteria gastrica dextra*; and descending by the *pylorus*, meets the *plexus* that accompanied the coronary artery; and near the lesser curvature of the *duodenum*, forms a considerable network; into which not only the lymphatics from the spleen enter, but likewise those from the gall bladder; and those of the liver, which are very numerous, both in its convex and on its concave side. \* From this net-

\* The lymphatic vessels of the liver are painted by Nuck in his *Adenographia*, p. 64.



work go some branches under the *duodenum*, and others over it, these branches open into the thoracic duct, near the termination of the large trunk of the lacteals, as seen at (*m*) *Plate 3*. The thoracic duct therefore is the common trunk which receives the lymphatic vessels of the lower extremities, the lacteals, and the lymphatics of all the *abdominal viscera*.

With respect to the lymphatics of the larger *viscera*, (such as, the liver, the spleen, and the kidneys,) they are generally in two sets: one which lies upon the surface of the organ, and the other which accompanies the large blood vessels in its center. In the liver I have found these two sets communicate with each other, so that by injecting mercury into the lymphatic vessels which lie upon its convex surface, I have filled those  
which



which accompany the *pori bilarii* and *vena portarum* in its center. The greatest part of the lymphatic vessels which lie upon the convex surface of the liver, run towards its falciform ligament, and pass down by the side of the *vena cava*. But some of them run towards the right ligament of the liver, where they pass down upon the diaphragm to get to the thoracic duct. The lymphatics on the concave surface run towards the *portæ* where they join those which come from the center of the liver along with its large blood vessels ; It is remarkable of those lymphatic vessels which run upon the surface of the liver, that their valves can readily be made to give way, so that I have injected them from their trunks to their branches, and to great minuteness; some preparations of which I have now by me.

It has been suggested by one of the best anatomists of this age\*, that the lymphatics of the stomach do not open into the thoracic duct like those of the other *viscera*, but only open into the sanguiferous veins of the stomach; but from repeated dissections of the human subject I am convinced of the contrary; and likewise from the analogy with other animals, particularly fish, whose lymphatic vessels either have no valves, or the valves readily give way, so that I have repeatedly pushed injections from the thoracic duct into the lymphatics of their stomachs, as I have also done into the lymphatics of the other *viscera* contained in the cavity of their abdomen; as will be more particularly mentioned hereafter.

The thoracic duct, which receives all the vessels that we have yet described, differs in its size in different subjects,

\* Dr. Meckel.

but

but is always smaller in its middle than at its beginning, as is seen in *Plate 3*. Sometimes its lower part at (*m*) is still larger in proportion than is there represented, and that enlargement has been called the *receptaculum chyli*, and is considerable in some quadrupeds, in turtle, and in fish : but many anatomists have denied that there is any part of the thoracic duct in the human subject that deserves the name of *receptaculum*, and my experience makes me subscribe to their opinion, as I have never seen any thing like a pyriform bag, as it has been described, but merely an enlargement not unlike a *varix*, and that only in few subjects : for commonly it appears, as in this plate, only a little larger than at its middle. This lower extremity of the thoracic duct is formed by the union of two, three, or four very large trunks of lymphatic vessels :

D 4

These



These large vessels unite so as to form the duct about the lower part of the first, or the upper part of the second *vertebra lumborum*; reckoning downwards.

These large lymphatic trunks which form the thoracic duct are spread out upon the spine, those of the right side lying below the right *crus diaphragmatis*, and those of the left passing between the *aorta* and the spine; whilst the thoracic duct itself lies on the right side of the *aorta*, between that artery and the right *crus diaphragmatis*, and behind the emulgent artery of the right side, as is seen *Plate 3* at *(n)*. From this part it passes upwards, being at first covered by the *crus diaphragmatis*, and afterwards appears at *(o)* in the *thorax*, upon the spine between the *aorta* and the *vena azygos*. In the *thorax* it receives some lymphatics from the intercostal spaces; a few

few of which are seen at (*p*) and afterwards it receives vessels from the lungs.

The lymphatics of the lungs are in two sets, one of which passes on the posterior part of each lobe by its root, into the thoracic duct near the middle of the thorax; and another set passes from the fore part of each lobe up towards the jugular and subclavian veins. Some of the lymphatics on the posterior part of the left lobe pass under the *aorta* to get to the thoracic duct.

At the root of the lungs, where the large blood vessels enter, are many glands called bronchial, they are generally of a blackish colour in the human subject, and have been suspected to secrete the *mucus* which is spit up from the *trachea*; but I have more than once distinctly filled them with mercury by injecting the lymphatic vessels of the lungs, and

and therefore it is evident that they are not mucous but lymphatic glands.

The lymphatic vessels from the anterior part of the left lobe of the lungs pass into the angle between the jugular and subclavian vein of the same side, joining the thoracic duct at its termination, whilst those from the fore part of the right lobe do not communicate with the thoracic duct, but pass into the angle between the right jugular and the right subclavian vein. These lymphatics from the anterior parts of the lungs are probably accompanied by those of the heart, which are represented by the accurate *Nuck* in his *Adenographia*, fig. XLI.

The thoracic duct, after receiving the vessels before mentioned; passes behind the ascending *aorta*, see *Plate iv.* and goes to the left side, terminating in the angle between the jugular and the sub-clavian



clavian vein. But, just before its termination, it generally goes higher up than the angle, and then bends down towards it, as is seen, *Plate iv, (b, c)*. Sometimes there are two thoracic ducts instead of one, but this rarely occurs in the human subject, but it is not unfrequent for the duct to split near the upper part of the *thorax*, and the two branches, after spreading out from one another, commonly unite again at their termination in the angle between the left jugular and subclavian veins. I never saw any part of the thoracic duct terminate in the right subclavian of the human body, though such a circumstance has been observed by others\*. But I have now by me a preparation where the duct splits at the upper part of the *thorax* into two branches, one of which enters the angle between the jugular and subclavian of the left side,

\* Dr. Meckel, *Epist. ad Hallerum*, p. 30.

and

and the other opens into the left sub-clavian vein, about half an inch on the outside of that angle.

In the description of the lymphatic vessels which lie near the spine, I have mentioned only a few glands, and in *Plate 3*, where those vessels are exhibited no glands are represented. This I at first considered as an imperfection in the preparation, and had intended to make a drawing from another, but there are two reasons which have induced me to lay the present one before the reader. First, the lymphatic glands are not constant, either in number or situation ; and therefore the describing them particularly in any one subject is less necessary, since we cannot be sure of finding them exactly the same in any other. Secondly, the injecting the lymphatic vessels from the groin to the neck, without filling one lymphatic gland, proves a fact which is contradictory

dictory to the received opinion concerning those vessels, viz. that they always pass through glands in their way to the blood vessels, so that if these glands were obstructed, a dropsy must be an inevitable consequence, which is not strictly true when we speak of the lymphatic vessels in the *abdomen*, where, I find, besides the vessels which go into the glands, there are generally some which escape them. The same is true with respect to the lacteals, so that an obstruction of the mesenteric glands may not always produce a *marasmus*, as a part of the chyle may pass the glands and get into the thoracic duct.

But although no lymphatic glands are represented in this plate, it may be necessary to mention where they are commonly seen.

The



The mesentery of the human subject is well known to contain a considerable number of them ; they are likewise found in the *mesocolon* where the lymphatics of the large intestines pass through them. The stomach has also several glands which belong to its lymphatic vessels, and lie near the *arteria coronaria*, and the *gastrica dextra*. There are likewise a few upon the *omentum* in some subjects, and there are also many glands by the sides of the *pancreas*, particularly near the lesser lobe of that *viscus*, close to the *duodenum*.

Besides these glands which belong to the intestinal tube, there are many more in the cavity of the *abdomen*, and a few in the cavity of the *pelvis*, which belong to the lymphatic vessels of the other organs.

There

There is commonly a pretty considerable gland seen just on the inside of the edge of the tendon of the external oblique muscle, called *pouparts* ligament, on the outside of the *illiac* artery; and there are others near that artery, where it lies upon the *psoas* muscle. There are likewise commonly one or two near the internal *illiac* artery in the cavity of the *pelvis*, and there is a considerable number generally met with by the sides, and upon the lumbar *vertebræ*. In the subject from which I took *Plate 3.* the spaces (*i,i,i,i*) were occupied by such glands, which were not injected, and therefore are not represented in that plate.

Near the spleen, liver, kidneys, and renal *capsulæ*, there are also lymphatic glands which belong to the lymphatic vessels of these organs.

There

There are likewise lymphatic glands sometimes observed by the sides of the thoracic duct, particularly about the middle of the *thorax*, which glands belong principally to the vessels of the lungs.

There are also many lymphatic glands (called bronchial) near the root of the lungs, these glands are placed upon the lymphatic vessels, just where they quit the lungs. But no lymphatic glands have yet been observed in the substance of the lungs, and the tubercles which some suspect to be obstructed lymphatic glands, seem to have a different origin. There are likewise some glands seen on the lymphatic vessels which lie near the sub-clavian veins at the upper part of the *thorax*, and which belong to the fore part of the lungs.

Besides these there are some lymphatic glands upon the *aorta* near the *œsophagus*, and there are also others occasionally



asionally met with in the intercostal spaces, and there are generally two or three contiguous to the thoracic duct at the lower part of the neck and upper part of the *thorax*, near the termination of that duct, in the angle between the left jugular and the left subclavian vein.

Having thus traced the lymphatic system in all parts of the body that are below the termination of the thoracic duct, I shall next examine that part of it which lies upon the head, neck, and upper extremities, where the tracing it is attended with greater difficulties.

By the side of each internal jugular vein is a large lymphatic vessel, which is the trunk of those of one side of the head and neck, that of the right side is seen *Plate IV. (1)*. There are likewise smaller lymphatics which are seen near the branches of the external carotid artery. There are also lymphatic glands by the sides of the parotid and maxillary

illary glands, and by the sides of the large artery where it lies upon the chin, and by the side of the occipital artery; and I have seen one upon the root of the mastoid process of the *os temporis*. Those glands, which accompany the lower part of the artery that runs upon the face, are sometimes swelled in consequence of absorption from the lips and the parts adjacent, and also from gum-boils; and those which accompany the occipital artery are frequently enlarged in consequence of the absorption of matter from wounds of the scalp; from which facts it is evident that the external parts of the head are supplied with lymphatic vessels. In quadrupeds I have distinctly seen those vessels, particularly in a dog and in an ass, by passing a ligature round the large blood vessels of their necks immediately after killing those animals. These experiments I made with a view to determine whether the brain had lymphatic vessels, but



but I never yet have been able to see any on that organ; neither when I tied up the lymphatics on the necks of those animals, and thereby stopt the course of the lymph; nor when I dissected the human brain, which I have carefully done several times with the view to discover those vessels, and have particularly sought for them in the *plexus choroides* where they have been suspected to be seen, and near the *glandula pituitaria* which is supposed by some to be a lymphatic gland, but improperly, since neither that gland nor the *glandula pinealis* agrees with the lymphatic glands, as I shall shew in the third part of these inquiries.

But although lymphatic vessels have not yet been demonstrated in the brain, it is probable from analogy, that this organ is not destitute of them; and the following case affords an argument in favour of absorption being carried on



here by lymphatics, as well as on other parts of the body.

J. H. a young man of twenty five years of age, by trade a silk dyer, and whose father at that time laboured under a third attack of madness, consulted me about a glandular tumor upon the left side of his neck, of which he gave the following account: that for some time he had been troubled with an eruption which had gone off and returned repeatedly; that a week after its last disappearance, he was seized with a fixed pain in his forehead, for which he was bled; that one day whilst at work, after this pain had continued a fortnight, he felt a weakness in his left arm, and the brush with which he was working fell out of his hand, but he had no weakness in his right arm, nor in his legs. That this weakness returned two or three times a day for nine days; and was rather relieved

lieved by putting his hands into warm water. About three days after he was first attacked with this weakness, a tumor appeared on the left side of his neck, just below the ear, when I first saw him this tumor had continued eleven days. It seemed to be an enlarged lymphatic gland, was then hard, but afterwards gradually came to suppuration, and at the end of six weeks it burst and discharged a yellow curdled matter. He adds at the same time that he was attacked with the weakness, he had a faltering in his speech, and slight convulsions in his lips.

Now as in this case there seemed to be a compression of the brain, which was removed when the glands swelled, is it not probable that the cause of the compression had been some extravasated fluid, which afterwards being absorbed, occasioned

the tumor and suppuration of the lymphatic gland? and therefore is it not a presumption that absorption is here likewise carried on by lymphatic vessels?

The small lymphatics which accompany the branches of the external carotid artery unite upon the neck, and form a large trunk which accompanies the internal jugular vein, passing through some lymphatic glands, near the termination of this trunk in the angle between the jugular and subclavian veins; there are likewise some glands on the outside of this angle, which seem to belong to the lymphatics from the back of the neck, and of the shoulder.

The *Glandula Thyroidea* has many lymphatic vessels, which can sometimes be inflated by blowing air into the cells of the gland: these vessels pass on each side of the *trachea*, one part going into the



the angle of the right subclavian and jugular, and the other joining the thoracic duct upon the left side. They are seen in *Plate IV.* at *f.*

So much for the lymphatics of the head and neck, I shall next proceed to describe those which belong to the arms.

Each arm, like the leg, has two sets of lymphatic vessels, one which lies immediately under the integuments, and belongs to the skin and cellular membrane connecting it to the muscles; and the other which accompanies the large arteries, and belongs to the parts deeper seated.

The superficial set of lymphatic vessels may be discovered in emaciated dropfical subjects, by a careful dissection on the fore and back part of the arm,

E 4

where

where I have fixed pipes into them and have injected them with mercury. In *Plate V.* they are seen running on the back part of the fore arm as at (a,a,a), most of them passing on its outside, and twisting to the fore part, near the head of the *radius*, as at (B). But there is one vessel in this preparation which passes towards the inside, under the inner condyle of the *os humeri* at (c), and sends a branch amongst the muscles, which branch perforates the interosseous ligament, getting between the *radius* and *ulna* to the fore part, where it joins a deep seated one that had accompanied the radial artery.

In *Plate VI.* the lymphatic vessels are seen on the fore part of the upper extremity; those superficial branches which passed on the outside of the back of the fore arm appearing now on the fore part at (b) and ascending under the skin

skin that covers the *supinator longus* and the *biceps*, they enter some glands in the *axilla* at (*f, f*), whilst that vessel which passed on the inside of the back of the fore arm under the internal condyle, appears on the fore part at (*c*), and just above the condyle enters a gland (*d*), and then passes up on the inside of the arm, communicating with a lymphatic from the fore part of the wrist, and passing to the axillary glands.

A superficial lymphatic vessel is seen under the skin, on the fore part of this extremity just above the wrist, a pipe was introduced at (*a*), and the lymphatic thereby injected with mercury. This vessel passes under the integuments over all the muscles, and joins the lymphatic from the back part of the fore arm at (*e*), and there forms a *plexus* which passes under the integuments, on the inside of the arm to the axillary glands at (*f*).

Besides



Besides these superficial lymphatic vessels upon the upper extremity, I have traced a deeper seated one near the radial artery, and have injected it from a pipe fixed at (g). This vessel accompanies the radial artery, and passes, first under the interosseous, and then under the ulnar artery which in this subject runs over the muscles. Near the part where it passes under the interosseous artery, it receives the branch (as formerly mentioned) from the back of the fore arm, After passing under these arteries, this lymphatic appears on the inside of the brachial artery at (i), where it is deep seated, ascending close to that artery, and near the middle of the arm, passes through the two glands (k, k), after which it appears considerably enlarged, and goes under one of the *arteriæ anastomaticæ* at (l, m), and then ascends to the lymphatic glands in the *axilla*.

But

But these vessels, though filled more successfully in this extremity than in any other that I ever injected, are only a part of the larger lymphatic vessels of the arm, as there are probably some accompanying the ulnar and interosseous arteries, although not here injected: and they should moreover be considered as only trunks of the lymphatics, since it is probable, that every (even the smallest) part of this, as well as all other parts of the body, has one of these vessels adapted to absorption: that this is the case seems to be proved by the experiments made with the variolous matter, for at what part soever of the arm that matter is inserted, the lymphatic vessels take it up and carry it into the body, as can be traced by its inflaming the conglobate glands through which these vessels pass.

In *Plate IV.* the termination of all these lymphatic vessels is exhibited.

Two



Two of the trunks of those of the left arm are seen at *d, d*, which pass under the clavicle, whose cut end is seen at *D*, and under the subclavian vein *S*, where, having joined, they form the large trunk (*e*), which appears just above the left subclavian vein, and joins the extremity of the thoracic duct at its entrance into the angle between that vein and the jugular. That these lymphatics commonly join the thoracic duct, as is here described, I am persuaded from having seen it distinctly in three subjects. But that they may, in some instances, open into the subclavian vein before they reach the angle, I think is likewise probable from having observed it in the case above mentioned, in which case, the thoracic duct having split into two trunks, one of these trunks, instead of entering the angle between the veins, opened into the subclavian itself, about an inch from the angle ; but this circumstance I  
should



should consider as only an exception from a general rule.

The thoracic duct is not only joined by this trunk of the lymphatics of the left arm, but also by the lymphatic vessels of the left side of the thyroide gland, which appear at (*f*), and by the trunk of the lymphatics of the left side of the head and neck, and also by those from the fore part of the lungs of the same side ; but neither of these appear in this plate.

The lymphatic vessels of the right side I have repeatedly traced with great care, particularly from their having been suspected to terminate in the subclavian vein, without reaching the angle between it and the jugular ; but I have always distinctly seen them go precisely into the angle, not only in the subject from which this plate was made, and which I now have by me, but also in  
three

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three others. When therefore these lymphatics are seen to enter the subclavian vein at any other part, I should consider it as only an accidental variety, like the double termination of the thoracic duct formerly mentioned.

These lymphatic vessels of the right side form four considerable trunks, which join near their termination. These trunks are, first, one from the upper extremity, which appears at (*k*), *Plate IV.* lying above the clavicle between the subclavian artery and vein: This trunk is formed by the lymphatic *g, g*, which comes up with the brachial artery, and the *plexus (b)*, which likewise belongs to the arm, and passes under the subclavian vein. Secondly, the trunk of the lymphatic vessels of the right side of the head and neck which passes down on the outside of the jugular vein, as is seen at (*l*). Thirdly, a lymphatic from the thyroide gland,

gland, which lymphatic is seen at (*m*), passing under the right jugular vein to get to the others. Fourthly, the trunk of the lymphatics from the fore part of the lungs of the right side, which trunk I have distinctly traced under the subclavian vein to its termination, in common with the others, at the angle between the jugular vein and the subclavian.

To finish this description, I shall observe that it is the more necessary to understand the exact termination of these lymphatics of the right side, in order to explain how tumors about this place, by compressing those vessels, occasion œdematous swellings of the parts from which the vessels come, without affecting the other parts of the body.





## C H A P. IV.

*A Description of the Lymphatic System in Birds\*.*

**T**HIS System consists in birds, as it does in the human subject, of three parts, *viz.* the lacteals, the lymphatic vessels, and their common trunk the thoracic duct.

The lacteals indeed, in the strictest sense, are, in birds, the lymphatics of the intestines, and like the other lymphatics carry only a transparent lymph. And instead of one thoracic duct there  
are

\* This description has already been printed in the Philosophical Transactions, Vol. LVIII. where I have added a plate, which was thought unnecessary in this book.

are two which go to the two jugular veins. In these circumstances, it would seem, that birds differ from the human subject, so far at least as I may judge from the dissection of a goose, which was the bird I chose as most proper for this inquiry, and from which I took the following description, after previously injecting its lymphatic system with quick-silver.

The lacteals run from the intestines upon the mesenteric vessels. Those of the *duodenum* pass by the side of the *pancreas*, and probably receive its lymphatics: afterwards they get upon the cœliac artery, of which the superior mesenteric is a branch. Whilst they are upon this artery they are joined by the lymphatics from the liver; here they form a *plexus*, which surrounds the cœliac artery; at this part they receive a lymphatic from the gizzard; and a little farther, another from the lower

or glandular part of the *œsophagus*. Having now got to the root of the *cœliac* artery, they are joined by the lymphatics from the *glandulæ renales*, or renal *capsulæ*; and near the same part, by the lacteals from the other small intestines, which vessels accompany the lower mesenteric artery. These last mentioned lacteals, before they join those from the *duodenum*, receive from the *rectum* a lymphatic which runs with the blood-vessels of that gut. Into this lymphatic some small branches from the kidneys seem to enter, which coming from those glands upon the mesentery of the *rectum*, at last open into its lymphatics. At the root of the *cœliac* artery, the lymphatics of the lower extremities probably join those from the intestines. The former I have not yet traced to their termination, though I have distinctly seen them on the blood-vessels of the thigh; and in one subject, which I injected, some vessels were filled,



filled, contrary to the course of the lymph, from the network near the root of the cœliac artery; these vessels ran behind the *cava*, down upon the *aorta*, near to the origin of the crural arteries, and I presume they were the trunks of those branches which I had seen in the thigh. At the root of the cœliac artery, and upon the contiguous part of the *aorta*, a network is formed by the lacteals and lymphatics above described. This network consists of three or four transverse branches, which make a communication between those which are lateral. In the subject from which this description was taken, there were four. From this network arise the two thoracic ducts; of which one lies on each side of the spine, and runs upon the lungs obliquely up towards the jugular vein, into which it opens, not indeed into the angle between the jugular and subcla-

vian vein, as in the human subject, but into the inside of the jugular vein, nearly opposite to the angle. The thoracic duct of the left side is joined by a large lymphatic, which runs upon the *æso-phagus*, and can be traced as far as the lower or glandular part of that canal; from which part, or from the gizzard, it seems to issue. The thoracic ducts are joined by the lymphatics of the neck (and probably by those of the wings) just where they open into the jugular veins.

The lymphatics of the neck generally consist of two pretty large branches, on each side of the neck, accompanying the blood-vessels\*. Those two branches join near the lower part of the neck; and the trunk is, in general, as small, if not smaller, than either of the

\* These lymphatics in the necks of fowls were first discovered by Mr. John Hunter.

branches.

branches. This trunk runs close to the jugular vein, gets on its inside, and then opens into a lymphatic gland. From the opposite side of this gland, a lymphatic comes out, which pours the lymph into the jugular vein. On the left side, the whole of this lymphatic joins the thoracic duct of the same side, but, on the right, one part of it goes into the inside of the jugular vein a little above the angle, whilst another joins the thoracic duct, and, with that duct, forms a common trunk which opens into the inside of the jugular vein, a little below the angle which that vein makes with the subclavian.

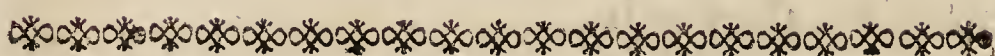
This system in birds differs most from that in quadrupeds, in the chyle being transparent and colourless; and in there being no visible lymphatic glands, neither in the course of the lacteals,



nor in that of the lymphatics of the *abdomen*, nor near the thoracic ducts.

For the sake of those who may incline to prosecute this inquiry farther, I shall relate the method by which these vessels may be demonstrated; and that is, having chosen a young and very lean goose, and fixed it upon a table, let the *abdomen* be opened whilst it is yet alive, and a ligature be passed round its mesenteric vessels, as near the root of the mesentry as possible. The lacteals will begin to appear near the ligature in a few minutes after it is made, especially if the bird has been well fed three or four hours before the experiment. The lymphatics in the neck may be shewn in the same manner; that is, by making a ligature on the jugular vein at the lower part of the neck; and to be more certain of including the  
lym-

lymphatics which are near it, we must take care not to pass the needle too close to that vein.



## C H A P. V.

*A Description of the Lymphatic System  
in one of the Animals called amphibious,  
viz. the Turtle.*

THIS system in a turtle, like that in birds, consists of the lacteals, the lymphatics, and their common trunks, the thoracic ducts. It agrees likewise with that in birds, in not having any lymphatic glands either on the mesentery or near the thoracic ducts; but differs from that in birds, in not having any glands upon the larger lymphatics of the neck; at least I am inclined to believe so, from not having seen any in the dissection of one animal



mal of this species in which I looked for them. It likewise differs from that in birds in another circumstance, to be taken notice of hereafter. Whether it agrees with the same system in birds, in the transparency and want of colour in the chyle, I cannot take upon me to determine, as I did not see any of that fluid in this subject (a).

The following description I took from the animal, after I had injected the larger branches of this system with a coloured wax, and the smaller with quicksilver. To avoid my being misunderstood, when I speak of the situation of the different parts, I shall mention, once for all, that the description was taken from the subject as it lay upon its back; those parts being called highest which were nearest the

(a) In a crocodile, an animal of the same class, the chyle is white.

head,

head, those lowest which were nearest the tail, those posterior which were nearest the back, and those anterior nearest the belly (*b*).

The lacteals accompany the blood-vessels upon the mesentery, running by their sides, and communicate frequently across those vessels. Near the root of the mesentery they anastomose, so as to form a net-work, from which several large branches go into some considerable lymphatics lying on the left side of the spine. These last can be traced downwards almost to the *anus*, and belong to the parts situated below the mesentery, and particularly to the kidneys. At the root of the

(*b*) The animal, from which I took this description, was pretty large, measuring from the lower to the upper part of the shell two feet seven inches, and two feet two inches from side to side.

mesentery,

mesentery, on the left side of the spine, the lymphatics of the spleen join the lacteals, and immediately above this union a sort of *plexus*, or net-work, is formed, which lies upon the right *aorta* (for there are two *aortæ* in this animal). From this *plexus* a large branch arises, which passes behind the right *aorta* to the left side, and gets before the left *aorta*, where it assists in forming a very large *receptaculum* which lies upon that artery. From this *receptaculum* arise the thoracic ducts. From its right side goes one trunk, which is joined by that large branch which came from the *plexus* to the left side of the right *aorta*, and then passes over the spine. This trunk is the thoracic duct of the right side; for, having got to the right side of the spine, it runs upwards, on the inside of the right *aorta*, towards the right subclavian vein. And when it  
has



has advanced a little above the lungs, or within three or four inches of the subclavian vein, it divides into branches, which, near the same place, are joined by a large branch that comes up on the outside of the *aorta*. From this part upwards those vessels divide and sub-divide, and are afterwards joined by the lymphatics of the neck, which likewise form branches before they join those from below; so that between the thoracic duct and the lymphatics of the same side of the neck a very intricate net-work is made. From this net-work a branch goes into the angle between the jugular vein and the lower part or trunk of the subclavian: this branch, therefore, lies on the inside of the jugular, whilst another gets to the outside of that vein, and seems to open into it a little above the angle between that vein and the subclavian. I say seems to open, for  
the

the injection had not succeeded at this part so as to enable me to determine whether the last-mentioned branch did enter or not. Into the above-mentioned *receptaculum*, the lymphatics of the stomach and *duodenum* likewise enter. Those of the *duodenum* run by the side of the *pancreas*, and probably receive its lymphatics, and a part of those of the liver. The lymphatics of the stomach and *duodenum* have very numerous *anastomoses*, and form a beautiful net-work on the artery which they accompany. From this *receptaculum* likewise (besides the trunk already mentioned which goes to the right side) arise two other trunks pretty equal in size; one of which runs upon the left side, and the other upon the right side of the left *aorta*, till they come within two or three inches of the left subclavian vein; where they join behind the *aorta*, and form  
a number



a number of branches which are afterwards joined by the lymphatics of the left side of the neck: so that here a net-work, or *plexus*, is formed, as upon the right side. From this *plexus* a branch issues, which opens into the angle between the jugular and the lower part or trunk of the subclavian vein. In these net-works, formed by the lymphatics near their terminations in the veins, this system in the turtle likewise differs remarkably from that in birds.

So much for the general description of the lymphatic system in this animal, I shall next add what I have remarked as to the more minute distribution of its lacteals. In the first place, it may be observed, that what knowledge we have of the minute distribution of those vessels in quadrupeds has been acquired from examining them when filled  
with



with their natural fluid, the chyle; for the valves with which those vessels abound prevent our injecting their smaller branches, as we do those of the arteries and veins of the intestines. But in this animal, I have been so fortunate as to force the valves, and to inject the lacteals from their trunks to their branches, so as to fill them all around with quicksilver, in several parts of the intestine. In these experiments I observed, that the quicksilver was often stopped by the valves, where the lacteals run upon the mesentery, or where they are just leaving the intestine; but when those valves were forced, and the quicksilver had once got upon the surface of the gut, it generally ran forward without seeming to meet with any obstacle. The lacteals anastomose upon the intestines, so that the quicksilver, which has got upon them by one vessel, in general, returns

returns by another, at some distance. The larger lacteals, which run upon the intestines, accompany the blood-vessels; but the smaller lacteals neither accompany those vessels, nor pass in the same direction, but run longitudinally upon the gut, and dip down through the muscular coat into the cellular or nervous, as it has been called, which in this animal is very thin in comparison to what it is in the human subject. So far I have traced those vessels to my satisfaction; but what becomes of them after they have got to the cellular coat is not so easy to determine: in five or six different experiments which I have made, the mercury passed from the lacteals into the cells between the muscular coat and the internal, and spread from cell to cell, very uniformly, over a great part of the intestine, although but little force had been used, and although there

there was nothing like extravasation in any other part of the intestine. Upon inverting the intestine, after thus filling its lacteals, the mercury, on being pressed, was, in many parts, driven into small vessels upon the internal coat, or villous, as it is called. From whence it would seem, that this cellular net-work was a part of the lymphatic system in this animal. It might indeed be supposed to be mere extravasation; but that it is rather a part of the lymphatic system appears probable from the following considerations. First, from the regularity in the size of the cells. Secondly, from the little force used in the experiment, and from there being nothing like this appearance in the cellular membrane between the peritoneal and the muscular coat, where extravasations were as likely to happen. Thirdly, from my having been able, after inverting the intestine,



to press the quicksilver from the cells into the very small vessels upon the internal coat ; but I must confess these facts would not be sufficient to determine whether these cells were, or were not a part of the system, did not the analogy of the same part in fish clearly prove it. For in the cod, instead of the cellular net-work, as in the turtle, there is a net work of vessels (of which a description shall be given in the next chapter) so that I have now no doubt but that those cells are parts of the lymphatic system, and that the small absorbent vessels of the internal coat pour their fluid into this net-work, from which it is conveyed by the larger lacteals.



C H A P. VI.

*The Method of discovering the Lymphatics  
in Turtle and in Fish, together with a  
Description of those Vessels in a Haddock.*

**I**N the foregoing chapter on the lymphatic system in a turtle, I have made no mention of the manner of discovering those vessels, because there is no difficulty in doing it; for in that animal the mesentery being very thin and transparent, and the lacteals pretty large, they are more readily observed than in any other animal; thence it happened that I saw those vessels in a turtle so long ago as 1763, which was before I discovered them in birds and fish.

But although it was an easy matter to see those vessels in the turtle, yet it was far from being so in birds and fish ; as the reader will readily believe, from their having been so often sought for in vain by so many eminent anatomists, particularly of this age. I may add, that the discovery in birds did not give me so much trouble as that in fish, though now, since I have once seen them, I can more readily find them in fish than in birds or quadrupeds. After seeing them in birds, and in one of the *amphibia*, I was very desirous of determining whether fish were, or were not provided with those vessels. This I endeavoured to do in the same way that I had found them in birds, that is, by tying up the mesenteries of live fish ; and for this purpose I went frequently to the markets, and examined several small ones. I likewise dissected some larger, when  
dead



dead, but in vain. I next went to Brighthelmstone, where I found kingston, or monk-fish, a species of skate. These being very large, and having a lean mesentery, seemed well fitted to my purpose. I opened two of them alive, tied up their mesenteric vessels, and put them again into the salt water; and though one of them lived an hour, I could not observe any lacteals either upon its intestine or its mesentery. After this, I repeatedly examined the intestines and mesenteries of common skate and cod, and at last was so fortunate as to discover the lacteals, and get a pipe into one of those vessels on the mesentery of each of these fish; and, injecting by this pipe, I found where the larger vessels lay; after which there was but little difficulty in tracing the whole system. I have now seen those vessels in a variety of fish, and shall give a descrip-

tion of them from a haddock. I shall proceed exactly in the order which I have found most convenient for tracing out the whole system for demonstration, beginning with one of its branches, which, as lying nearest the surface, must, of course, be divided before the other parts can be exposed to view. The account being taken from the fish as it lay on its back, those parts are called superior which are nearest the head; those inferior which are towards the tail; those posterior which are towards the back, and those anterior which are towards the belly.

On the belly of the fish, exactly in the middle line, is a lymphatic, which runs from the *anus* upwards; this lymphatic belongs not only to the *parietes* of the belly, but to the fin below the *anus*. It runs up towards the head, passes between the two pectoral fins,  
and

and, having got above them, it receives their lymphatics. It then goes under the *symphysis* of the two bones which form the *thorax*, where it opens into a net-work of very large lymphatics, which lies close to the *pericardium*, and almost intirely furrounds the heart. This net-work, besides that part of it behind the heart, has a large lymphatic on each side, which runs upon the bone of the *thorax* backwards, and when it has got as far as the middle of that bone, it sends off a large branch from its inside to join the thoracic duct. After detaching this branch, it is joined by the lymphatics of the thoracic fins, and, soon after, by a lymphatic which runs upon the side of the fish. This last-mentioned vessel consists of a trunk running on the side just opposite to the ribs, and from this trunk proceed branches on each side immediately under the skin; so that it has a



88      *Of the Lymphatic System.*

beautiful penniform appearance. Besides these branches, there is another set, deeper seated, which accompanies the ribs. After the large lymphatic has been joined by the above-mentioned vessels, it receives the lymphatics from the posterior extremities of the gills, and having now got as far back as the orbit, it next receives lymphatic vessels from that cavity ; but these vessels do not belong merely to the orbit ; for one of them comes from the nose, and another from the upper part of the mouth. A little below the orbit another net-work appears, consisting, in part, of the vessels above described, and of the thoracic duct. This network is very complex ; some of its vessels lie on each side of the muscles belonging to the gills, and from its internal part a vessel goes into the jugular vein, by which vessel the whole system is terminated. The large lymphatic  
phatic

phatic above mentioned, which lies upon the bone of the *thorax*, has likewise a process running towards the upper part of the kidney, and receives some of the lymphatics of that organ.

The lacteals run on each side of the mesenteric arteries, anastomosing frequently across those vessels. The *receptaculum*, into which they enter, is very large in proportion to them, and consists, at its lower part, of two branches, of which one lies between the *duodenum* and stomach, and runs a little way upon the *pancreas*, receiving the lymphatics of the liver, *pancreas*, those of the lower part of the stomach, and the lacteals from the greatest part of the small intestines. The other branch of the *receptaculum* receives the lymphatics from the *rectum*, and the lacteals from the greatest part of the small intestines. The *receptaculum*,  
formed

formed by these two branches, lies on the right side of the upper part of the stomach, (or the lower part of the *æsofagus*) and is joined by some lymphatics from that part; and also by some small vessels from the sound, and from the gall bladder, which, in this fish, adheres to the *receptaculum*. The thoracic duct takes its rise from the *receptaculum*, and lies on the right side of the *æsofagus*, receiving lymphatics from that part; and running up a little way (*viz.* about half an inch in this fish) it divides into two branches or ducts, one of which passes under the *æsofagus* to the left side, and the other goes straight up, on the right side, passes by the upper part of the kidney, from which it receives some small branches, and, soon after, is joined by a branch from the large lymphatic that lies above the bone of the *thorax*, as formerly mentioned.

It



It likewise, near this part, sends a branch to join the duct of the opposite side, and then, a little higher, is joined by those large lymphatics which make a net-work behind the heart, as is above described. These last mentioned vessels receive the lymphatics from the anterior, or superior part of the gills, and from the *fauces*. The thoracic duct, after being joined by these vessels, communicates with that net-work near the orbit; where its lymph is mixed with that of the lymphatics from the posterior part of the gills, from the superior fins, belly, &c. and then from this net-work a vessel goes into the jugular vein, just below the orbit. This last vessel, which I call the termination of the whole system, is very small in proportion to the net-work from which it rises; and indeed the lymphatics, at this  
part

part, are so large as to exceed, by far, the size of the sanguiferous vessels.

The thoracic duct of the left side, having passed under the *œsophagus* from the right, runs on the inside of the *vena cava* of the left side, receives a branch from its fellow of the opposite side, and joins the large lymphatics which lie on the left of the *pericardium*, and a part of those which lie behind the heart, and afterwards makes, together with the lymphatics from the gills, upper fins, and side of the fish, a net-work, from which a vessel passes into the jugular vein of this side. In a word, the lymphatics of the left side agree exactly with those of the right, as above described.

Besides these vessels, there is yet another part of the system which is deeper seated, lying between the roots  
of

of the spinal processes of the back-bone : this part consists of a large trunk, that begins from the lower part of the fish near the tail, and, as it ascends, receives branches from the dorsal fins, and from the adjacent parts of the body. It goes up near to the head, and sends a branch to each thoracic duct, near the part where these ducts come off from their common trunk.

This description, though taken from a haddock, agrees, I believe, pretty exactly with the distribution of those vessels in the cod, whiting, and perhaps all other fish of the same shape.

To this general description I shall add, what I have observed of the more striking peculiarities of this system in fish.

In the first place, those vessels are remarkable in not having any lymphatic  
phatic



phatic glands, that I can discover, in any part of their course. In this they agree with the turtle, but differ from birds, which have lymphatic glands on the vessels of their necks.

Secondly, these vessels in fish either have no valves, or the valves readily give way, for it is an easy matter to fill them contrary to the course of the lymph. When I first observed this circumstance, I imagined, that by injecting minutely those vessels, I might discover their very beginnings, and that I might also be enabled to determine, whether such parts as the brain, eye, &c. of which the lymphatics have not been yet seen in any animal, have, or have not such vessels. What success I have had in these experiments will be related in a future publication.

Thirdly, the lacteals in the cod (and I presume in most other fish) are remarkable

markable for having a beautiful network of vessels between the muscular and villous coat of the intestines (c). This net-work may be filled from the lacteals on the mesentery with the least force imaginable. If mercury be injected into this net-work at one part, it spreads over the intestine; the communications in the net-work being very numerous: if the intestine be inverted, and the mercury squeezed, it is easily driven into the small vessels of the *villi* of the internal coat\*. From these vessels the mercury can be forced into the cavity of the intestine; but not so easily as to make it clear, whe-

(c) I have seen this net-work in the turbot, plaice, and cod.

\* If instead of mercury a thin size be used, as an injection, it will run with the same facility into the lacteals upon the villi, as it would do into their arteries and veins, when thrown in by a pipe fixed in those vessels.

ther

ther they have, or have not a valve at their beginning. In these circumstances there is a strong analogy between fish and the turtle; but in fish it is more evident that there can be no deception as to the net-work between the muscular and the internal coat; for in them it is made up of cylindrical vessels, and is not cellular as in the turtle, and therefore not in the least like an extravasation: and in fish the vessels on the internal coat are larger than in the turtle.

Fourthly, this system agrees with that of the turtle, in having a very large *receptaculum*, and in having the net-work of large vessels near its termination in the sanguiferous system; and likewise in having the vessel, which goes from the net-work into the vein, small in proportion to the size of that net-work: so that the lymph must be  
lodged



lodged some time in those parts before it is poured into the mass of blood. In birds I also observed something like this, their lymphatic system being enlarged, or varicose at different parts; but these enlargements are small in proportion to those abovementioned in fish and turtle.

As to the manner of discovering those vessels in a fish, one might naturally suppose, that when it is known where the *receptaculum*, or any of the larger parts of this system lie, it could not be difficult to find them; but the coats of these vessels are so thin and transparent, that it is by no means easy. The readiest way of finding the whole system is, to look for one of the vessels which lie close to the skin; as, for instance, that which runs up exactly on the middle of the belly of the haddock, cod, and other fish of

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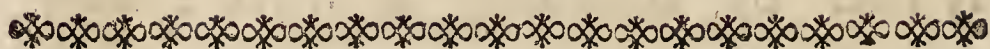
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the same shape. This vessel is easily seen as it grows pretty large at its upper part, near the head; and if a pipe be introduced, the whole system may be filled by its means.

It is partly owing to the ease with which those vessels may be seen, after discovering where their larger branches lie, that I have not added a figure of this system in a fish. Indeed it would be almost impossible to express all its parts in one figure, from the numerous and intricate communications of those vessels near their termination in the common veins. But I formerly laid before the Royal Society a haddock with its lymphatics and blood-vessels filled with coloured injections, to be compared with the description which was printed in the Philosophical Transactions, Vol. 59. And those that are desirous of prosecuting this subject

subject further, will, I flatter myself, find it an easy matter to fill the whole system by attending to what I have said above.





## C H A P. VII.

*On the Properties of the Lymph contained in the Lymphatic Vessels, and of that which lubricates the different cavities of the Body.*

**A**S the fluid contained in the lymphatic vessels resembles water in the circumstances of transparency and want of colour, thence their first discoverers denominated these vessels *ductus aquosi*, and seem to have concluded that the lymph was nothing but water.

This opinion some of the succeeding physiologists, particularly the learned *Boerhaave*, rendered more probable, by  
supposing

supposing that there were three series of arteries; the sanguiferous, the seriferous, and the lymphatic; and that those lymphatic vessels we are now describing were only veins corresponding to the lymphatic arteries, to restore their lymph to the heart. Thence the lymph seems to have been concluded the thinnest part of our fluids; in which opinion physiologists were confirmed by *Leeuwenhoeck's* theory, that the globules of lymph were smaller than those of the serum, or of the red part of the blood.

The fluids that moisten the different cavities of the body, *viz.* that of the *peritoneum*, *pleura*, *pericardium*, &c. being suspected to be formed solely from the condensation of that steam which appears on opening an animal just killed, have thence been also considered as mere water by some anatomists

and phyfiologists, who were confirmed in this opinion by observing, that in dropfies, where a great quantity of fluid is let out from fuch cavities, it is commonly a mere water, feldom coagulating either when expofed to the air or to heat\*.

But notwithstanding the plaufibility of all the arguments from which fuch conclufions were made, with refpect to thefe fluids, it will appear in the fequel, that although they be fo tranfparent in living animals, and fo watery in dropfies, yet in animals in health they differ fo much from water, that they not only coagulate when expofed to heat, but alfo when merely expofed to the air; in which circumftance they agree moft with that part of the blood

\* Agreeably to this opinion, thefe dropfies are faid to be occafioned by an *increafed fecretion*, or an *impeded abforption*, which fupposes that the fluids, naturally moiftening thefe cavities, are the fame as thofe let out from them in dropfical cafes.

called



called the coagulable lymph, as is evident from the following experiments\*.

EXPERIMENT I.

If soon after killing an animal in health, the *abdomen*, *thorax*, or *pericardium* be opened ; and if a little of the fluid that moistens these cavities be collected, which (even in cases where the quantity is very small) may be done by gently scraping the surface of these cavities with a wet tea-spoon, and if the fluid thus collected be suffered to rest, exposed to the air, it will jelly as the coagulable lymph of the blood does. This is an experiment which I have made on a considerable number of animals, viz. on bullocks, dogs,

\*. From amongst those who concluded these fluids a mere water should be excepted M. de Haller, —See his *El. Phys.*—And Professor Monro says, they coagulate by cold and rest. *Ob. An. and Ph.* p. 68.

geese and rabbits, and the result of all the experiments was the same.

## EXPERIMENT II.

If immediately after killing an animal in health, a lymphatic vessel be tied up properly, and then cut out of the body and opened, so as to let out the lymph into a cup and expose it to the air, it will jelly as the coagulable lymph of the blood does in the same circumstances; this experiment I have likewise made several times on dogs, asses and geese.

With respect to that fluid which moistens the cellular substance, or cellular membrane, as it is called, I cannot speak with so much precision, since it cannot be collected in animals in health; but when we consider how great a probability there is of the lymphatic  
phatic

phatic vessels absorbing that fluid, we may suspect that it is similar to what moistens the *pericardium*, *thorax*, *abdomen*, &c. especially as I have repeatedly observed, that the lymph returning from the extremities by their lymphatic vessels, coagulates when exposed to the air equally as the lymph nearer the center of the body.

Since then, those fluids in healthy animals coagulate spontaneously on being exposed to the air, may we not conclude that they resemble the coagulable lymph of the blood at least more than they do the water, or even than they do the *serum*, which does not jelly on being exposed to the air? And is it not an argument in favour of this inference, that such a fluid appears fitter for the office of lubrication than mere water, and more similar to the *synovia*, which of all fluids is the best adapted to that purpose?

But



But although from these experiments I am convinced that the lymph in these cavities and vessels of an healthy animal will always jelly on being exposed to the air, yet I have likewise observed that the strength of that jelly is different in different animals. In geese these fluids jelly sooner than in dogs; and in the same animals the jelly differs in the different circumstances of health: in most of the dogs which I examined the contents of the lymphatics formed a strong jelly, but in a dog which I had fed eight days with bread and water, and that rather sparingly, the lymph formed a very weak jelly; and in young geese, these fluids are later in jelling than in such as are full grown. I have observed the same of the fluid contained in the *pericardium* and *abdomen* of other animals, which fluid, when in a small quantity, always  
formed

formed a strong jelly, but when more copious, and the animal more feeble, the jelly was thinner; and in dropfical cafes, it is well known that the fluid let out of these cavities is not observed to jelly on being exposed to the air, as it does in animals in health; but in some cafes it is found to coagulate by heat, like the serum of the blood, and in others it only becomes a little turbid when boiled, owing to the coagulable matter being in very small proportion to the water.

Although this lymph becomes more watery in a weak state of the animal, it is less watery and more coagulable in some diseases.

But, what is a more curious fact, in those cafes where I have compared the fluid contained in the *abdomen* and *pericardium*, with that contained in their  
lym-

lymphatic vessels, of animals in different states of health; I have always found them agree with one another in the degree of coherence of the jelly which they formed. For, when the animal was in perfect health, the lymph from the cavity of the *pericardium*, *abdomen* and *pleura* formed a strong jelly, and that in the lymphatics of the neck and extremities was equally firm: When the animal was reduced, as in the dog fed eight days on bread and water, or when the goose was very young, then the jelly, formed by the fluid collected in these cavities, was weak, and that formed by the lymph in the lymphatic vessels was likewise weak in the same proportion. So that although these fluids vary in the different circumstances of health, yet they always agree with each other.

These fluids, likewise, as we have before observed, besides agreeing with  
one



one another, approach to the nature of the coagulable lymph of the blood in the circumstance of coagulating when exposed to the air, but they differ from it in the time necessary for that coagulation. In dogs that were seemingly in perfect health, whose blood, and whose lymph were let out of their vessels at the same time, the lymph was found to be much later in coagulating than the blood. The time which the blood requires for its coagulation is about seven minutes after exposition to the air, but the lymph let out from the lymphatic vessels of the same animals, was found to require half an hour, or more, for its coagulation. And although the blood coagulates soonest in the weak animals, yet the contents of the lymphatic vessels, or the fluids in these cavities do not, but seem later in jellying in proportion as the animal is reduced,

reduced, or as they become more watery.

Moreover, the coagulable lymph of the blood and the lymph of the lymphatic vessels, not only differ from one another in the time which they require for their coagulation when exposed to the air, but also they differ more evidently in the time required for their coagulation in the body when merely at rest without being exposed to air. As, for instance, in a dog killed whilst in health, and whose veins and lymphatic vessels were tied up immediately after his death, the blood in the veins was completely jellied in six hours, but the lymph in the lymphatic vessels of his neck was perfectly fluid twenty hours after his death, and, being let out at this time, jellied after being for some time exposed to the air.

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There is another change of the lymph very evident besides those already mentioned, for, it not only is varied from the natural state to the more watery, but also from the natural to the more viscid or coagulable; instances of which occur in those inflammatory crusts that are found, in some diseases, to cover the different parts of the body. Thus, the outside of the heart, and the inside of the *pericardium* are sometimes covered with a crust as tough as the size in pleuritic blood, and the surface underneath has marks of inflammation, but is not ulcerated. Probably, therefore, it is the inflammation which produces that change, or which makes the exhalant arteries secrete a lymph with such an encreased disposition to coagulate. Add to this, that the change which inflammation thus seems to produce is just the opposite  
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to that produced by the dropſy, for in the dropſy the fluid is ſecreted with an extraordinary quantity of water and too little coagulable matter; but in inflammations the fluid is ſecreted with a greater proportion of coagulable matter, and with leſs water; and in ſome inſtances it ſeems to be a pure coagulable lymph, either unchanged by the exhalants, and then coagulating gradually on being at reſt, as the coagulable lymph is found to do in the veins that are tied\*; or elſe the exhalant veſſels have the power of changing its properties, ſo as to make it coagulate in an inſtant after being ſecreted. And this ſuppoſition of the exhalants having a power of changing the properties of the lymph, is rendered probable from the following conſideration, *viz.* that it is ſometimes found coagulated in the inner ſurface of the heart, forming a

\* See Exp. Inquiries, Part 1ſt. Pag. 23.

crust, similar to what we so often see on the outside. Now as there is a constant current of blood through the heart, unless the lymph forming that crust had coagulated instantly on being secreted, it must have been washed off by the blood. One of the clearest instances of this was observed by Sir John Pringle, who has given me leave to transcribe from his notes the following circumstances of the case.

“ Mr. J——, who had for some time been subject to palpitations of the heart, and who (perhaps from another cause) happened to die apoplectic, was carefully opened after death, and two ounces of water were found in the ventricles of the brain.—

“ The heart was large, and adhered in some places to the *pericardium* in such a manner as parts adhere  
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from recent inflammation, that is by an exudation of coagulable lymph. In the *pericardium* was found a small quantity of bloody *serum*, of a dark brownish cast. There were marks of inflammation on the surface of the heart, and some part of the coronary artery was ossified. In the right ventricle, and in the pulmonary artery was a large concretion of the kind erroneously supposed a *polypus*, the upper part being white and fizy, whilst the lower had only the appearance of a dark coloured congealed blood: It was obvious that this concretion was formed after death. On the external surface of the left ventricle, near the *septum*, was a tumor, which, on being cut into, was found to contain above half a spoonful of a dark, reddish coloured matter of the consistence of *pus*, nor was there any doubt of its being



being produced by suppuration. This abscess would have broken into the left ventricle had not the opening through the *septum* been covered and shut up, on the side next that ventricle, by a crust, or *polypus*, of the shape, and about the size of half a large pigeon's egg, divided long-ways, so that the flat side lay towards the mouth of the abscess, whilst the convex side was turned towards the ventricle and occupied a space in it. This, adds Sir John Pringle, was a true *polypus*; it cut tough or like the coagulated blood of aneurysms of old standing, nor was there any doubt, from its appearance, of its having existed there for a considerable time."

Now this crust or *polypus*, lying over an inflamed surface, had probably been formed by a secretion of the lymph from the inflamed vessels;

and being formed in the cavity of the heart where there was a constant current of blood, the lymph of which it was composed, must, I think, have coagulated instantly on being secreted from the vessels, otherwise it would have been washed off with the current; and as the coagulable lymph is not naturally disposed to coagulate so instantaneously, it is probable that the diseased vessels here possessed the power of producing that change; and therefore, that as in dropical habits, where the vessels act weakly, the fluids exhaled are of a watery tenuity; so in inflammatory cases, where the vessels act strongly, those secreted fluids, in consequence of that strong action, acquire a more viscid and a more coagulable nature.

And moreover, as it appears that the properties of the lymph exhaled upon  
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surfaces, and into cavities, differ so widely in different circumstances, and as we find that *pus* is often met with in such cavities, without ulceration, is it not probable that *pus* itself is merely that lymph changed in its properties by passing through inflamed vessels. The cavities of the *pleura*, *pericardium*, &c. are sometimes observed to contain considerable quantities of *pus* without the least mark of ulceration. Instances of which I have seen. In one patient I found three pints of pure *pus* in the *pericardium*, without any ulcer either on that membrane, or on the heart. In another, the cavity of the *pleura* of the right side was distended with a *pus* that smelt more like whey, than a putrid fluid, and the lungs were compressed into a very small compass; but there was no appearance of ulcer or erosion, either on these organs or on the *pleura*, but only under the *pus* was



a thin crust of coagulable lymph. In such cases it is manifest the *pus* must have been formed from the fluids; and as the exhalant vessels at one time appear to secrete a mere water; at another a coagulable lymph; and in a third (when a little inflamed) they secrete that lymph so viscid, and change its properties so much as to make it coagulate instantly on being secreted; so in like manner they may sometimes, when more inflamed, have the power of converting the lymph into *pus*: and, according to the kind and degree of the inflammation, the *pus* may vary from the bland, viscid, and inodorous nature, to that of the most thin and foetid sanies found in phagedenic and cancerous ulcers. And, if *pus* in these cases is produced merely by a secretion, so likewise, it would seem probable, that even in abscesses, where there is a loss of substance, it is not  
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the melting down of the solids that gives rise to the *pus*, but the *pus* being secreted into the cellular membrane from its pressure, and from other causes, deadens the solids and then dissolves them, which is confirmed by observing, that even a piece of fresh meat, if put into an ulcer and covered up, is soon destroyed or melted down by the *pus*, which is thereby rendered more fœtid. And this opinion, that *pus* is made by a secretion, is strengthened by observing that in its pure state it is full of globules; in which circumstance it agrees with milk, which is produced by a secretion, and not by a fermentation\*.

Upon the whole then it appears, that the lymph contained in the lymphatic vessels, and the fluids which moisten the different cavities of the bo-

\* See Professor Morgan's ingenious Dissertation, de Puopoesi.



dy, as the *pleura*, *peritoneum*, &c. instead of being a mere water, in healthy animals, are coagulable fluids, approaching to the nature of the coagulable lymph of the blood, of which probably they are a species, or are composed of a mixture of that lymph with water, that the proportions of that mixture vary from the dropfical habit, where the coagulable lymph is in a small, and the water in a great proportion, up to the rheumatic or inflammatory habit, where the lymph abounds, and the water is in less proportion; and that in some cases, the lymph, in passing through inflamed vessels, is even converted into *pus*.





C H A P. VIII.

*Of the Manner in which the Lymph is secreted into the cavities, for their lubrication.*

**H**AVING in the preceding chapter spoken of the properties of the lymph moistening the different cavities of the body, I shall in this consider the manner in which that lymph is formed, or secreted from the mass of blood.

The most generally received opinions concerning this secretion have been, that it was performed either by small exhalant arteries, or else by pores on  
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the sides of the vessels, which pores were believed to be organized.

But these opinions have been controverted by a celebrated anatomist\*, who has endeavoured to prove that this secretion was not performed by exhalant arteries, or an effect of what is properly called organization, but merely by the thinner or more watery parts of the blood, filtrating or transfuding through the inorganized interstices between the fibres of our vessels and membranes: so that, according to this idea, the fibres of our vessels were close enough to retain the *serum*, or the red globules, but not close enough to prevent the water oozing out as through a sieve, and the arguments with which this doctrine is supported, are as follow:

\* Dr. Hunter.

First,

First, The ready transfudation of watery and other injections after death.

Secondly, The transfudation of blood after death, but not during life ; for during life he supposes the blood to be thickened by the coagulable lymph, but when that lymph is jellied, he concludes the blood is thereby made thinner, and therefore more capable of oozing through the inorganized interstices, by which it could not pass before.

Thirdly, The transfudation of bile, which he thinks takes place in the living body, because on opening a dead one we see all the neighbourhood of the gall-bladder tinged with this fluid\*.

Such are the arguments brought in favour of transfudation ; but on a care-

\* See Dr. Hunter's Medical Commentaries, Part 1st. p. 40.



ful examination, they are not so satisfactory as those which may be produced in defence of the opinion that these secretions are by organized passages, as I think will appear from the following observations.

First, Although fluids do transfuse on being injected into the vessels of the dead body, yet we must not thence conclude that a similar effect would certainly take place in the living, for it is probable, that “our fibres and “vessels have a degree of tension which “they may lose with life.” Besides, if transfusion took place in the living body, it would seem to defeat the principal purpose for which the blood-vessels were made, that is, the containing and conveying the fluids; and upon drinking a greater quantity than ordinary of watery liquors, instead of the liquors being carried to the kidneys

neys or other emunctories, and thereby thrown out of the body as a redundancy, they would escape into the cellular membrane and occasion an *anasarca*. That this would be the case will appear the more probable, when it is considered how small the fibres of our blood-vessels must be, and therefore what millions of pores (did they exist) the water would be exposed to from its entrance into the stomach, and its passage through the lacteals, the thoracic duct, the veins, the heart, the lungs and the arteries, before it reached the kidneys. So that were we in imagination to follow a drop of these liquors, according to the idea of transudation, we should find it, first leaking through the stomach or through a lacteal, then being absorbed, then escaping a second time, and being again absorbed, &c. an idea by no means consistent with what we know of the works

works of nature, who, as a learned and ingenious author says of her, “*Operam suam non ludit, neque quod actum est agit denuo\**.” It is more probable therefore, that as the blood-vessels are made to contain and convey the fluids, nature has taken care to construct them properly to prevent this purpose being defeated.

Secondly, To suppose that the fluids which moisten the different cavities of the body, as the *pericardium*, *pleura*, *peritoneum*, *tunica vaginalis*, &c. get into these cavities merely by transudation, is to suppose, not only that the small vessels in contact with these membranes have inorganized pores, but also that these membranes themselves have the same just opposite to those of the vessels. Now if we admit inorganized pores at one part of those membranes, we must admit them in all parts,

\* Dr. Glisson.

and



and in the same degree: But as the blood-vessels are circular, and touch those membranes only by a small part of the circle, the parts touched by the vessels must be smaller than the interstices between the vessels, and the lymph must have fewer chances in favour of its leaking from the vessels into the cavities, than of its oozing again from these cavities into the interstices between the vessels or into the cellular membrane; so that, if these membranes admitted of transudation, there would be no such thing as a partial dropfy, for the water would run out at one part of the *pleura*, *pericardium*, *peritoneum*, &c. as fast as it ran in by the other, and an *anasarca* would always accompany an *ascites*; which not being a fact leads us to believe, that those membranes do not admit of transudation in living bodies, and that the fluids get into them not  
by

by inorganic, but by organized passages.

Thirdly, To prove more satisfactorily that these fluids are not filtrated from the blood merely by inorganic transfusion, let us recollect the experiments related in the last chapter concerning the properties of those fluids, which we found varied in different circumstances of health. For, in inflammatory affections of the parts from which they were secreted, they assumed the appearance of the coagulable lymph of the blood, and formed a tough jelly; in animals in health they formed a jelly of a weaker nature; and in dropfical cases they were almost a mere water, without the property of coagulation. Now if these fluids be so variable in their properties, it is manifest that the passages secreting them cannot be always unalterably the same,



same, or inorganized; since at one time we find them secreting one fluid, and at another time secreting another; especially as we sometimes find them secreting a fluid very different from the blood, viz. *pus*. Which *pus* being found in cavities without any ulcer or erosion, we must conclude it formed by something more than a mere filtration; for we cannot suppose there should be filtrated from the blood a fluid that was not in it. And if *pus*, which passes from the same pores, can only be accounted for by supposing these pores to be organical, in like manner is it not probable, that the secretion of the natural lymph is not a straining through inorganical, but through organized passages?

Lastly. It has been brought as an argument in favour of transudation in the living body, that blood transudes

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after



after death, and this has been explained on the supposition that the blood was thicker before the coagulation of the lymph. Which supposition appears ill-founded, when we speak of the living body; for in former experiments\* we have observed that this lymph, frequently at least, rather thins than thickens the blood. If therefore the blood transudes in the dead and not in the living body, we should rather attribute it to a change in the vessels than in the blood, as is probable from a careful examination of that very fact which has been brought as the principal argument in favour of transudation, viz. the parts adjacent to the gall-bladder being tinged with bile; for any one who will take the trouble of standing by a butcher, whilst he kills a sheep, will find, contrary to that gentleman's conclusion, that upon

\* See Exp. Inquiries, Part 1st.

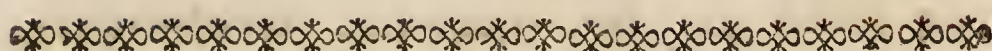
opening the animal immediately there is no appearance of the gall having transfused, for none of the parts surrounding the gall-bladder are tinged. But let the animal continue a day or two unopened, and then the gall will be found to have transfused, and to have tinged the neighbouring parts; as is the case in the human body by the time that we inspect it.

Since then the gall bladder so readily allows of transfusion after death, and not during life, is it not probable that there is in our membranes and our blood-vessels a degree of tension, or a power of preventing the fluids oozing out of them, which power is lost with life?

Upon the whole then it appears, that the interstitial lymph, or the fluid which moistens the different cavities

of the body, being different from mere water, cannot be produced simply by transudation through inorganic interstices; but that there are small exhalant arteries, or organized passages, which not only transmit it from the blood, but change its properties, and adapt it to the office of lubrication, and likewise make it assume very different appearances in different circumstances of health.





C H A P. IX.

*An Examination of the Opinion, whether  
the common Veins do the Office of Ab-  
sorption.*

**A**S there is a secretion upon the different surfaces, and into the different cavities of the body for the purposes of the constitution, so there is likewise an inhalation or an absorption. For example; If food be taken into the stomach and intestines, it is there digested, and being converted into chyle, it is in that form taken into the blood-vessels. If garlick be applied to the skin it gets into the body, and is smelt in the breath with as much

certainly as when taken into the stomach, where its juices are absorbed by the lacteals. So, likewise, terebinthinate medicines applied to the skin are soon smelt in the urine; and cantharides in a blister affect the urinary passages.

In the same manner fluids are taken from different cavities of the body into the vascular system. Thus the water of an *ascites* and an *anasarca* are occasionally taken up and carried by the blood-vessels to the intestines and kidneys, and evacuated by stool or by urine. And the *pus* of an abscess is sometimes absorbed, and carried to distant parts of the body and there deposited, or is evacuated by the intestines or urinary passages. So also fluids injected into cavities, as that of the chest or the belly of living animals soon find their way into the blood-vessels. These circumstances

circumstances are admitted by anatomists amongst the unquestionable facts of physiology.

Nor do anatomists differ in their opinions about the mode in which these fluids are taken up, for it is universally allowed to be by absorption, or that there are small orifices adapted to imbibe them; the only question is, what the vessels are to which these orifices belong, whether, to the lymphatic system, or to the common veins.

That the common veins did the office of absorbing both the chyle and the lymph, was the opinion of anatomists before *Asellius* discovered the lacteals; but after his time few doubts were entertained of the lacteals absorbing, at least, a part of that fluid. But most anatomists have been so tenacious of the old opinion as still to believe, that the veins partly performed that

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office,



office, or absorbed some of the chyle and carried it to the liver.

As to the absorption of the lymph; they have been still more positive of its being performed by the common veins; nay even after the discovery of the lymphatic vessels it occurred but to few, that these vessels contributed in the least to this absorption. And no wonder, since, besides the respect for the contrary opinion, because it was transmitted from antiquity, anatomists thought themselves possessed of many strong arguments in favour of the common veins performing absorption; and, as these arguments still continue to have weight with some modern physiologists, we shall make a particular examination of them in this chapter.

First. That the common veins arise from cavities, especially in the intestines,

tines, and do the office of absorption, is thought probable from injections into these veins in dead bodies having sometimes passed into those cavities, even in cases where but little force was used. This is a circumstance which has occurred in the experiments of the most eminent anatomists, both of the past and of the present age, so that there is no fact in anatomy in favour of which more respectable authorities might be produced. And yet whoever has made numerous experiments with injections, must be convinced how easy it is to be deceived by them in this matter. For the veins in dead bodies being easily ruptured, whenever we see injections get from them into cavities, we have reason to doubt whether these injections had passed by natural passages or by laceration of the small vessels; and whoever will examine the authorities that have been  
quoted

quoted in defence of this fact, will find that an equal degree of credit has been given to experiments made with such coarse materials as no experienced injector will now believe could pass through such small orifices\*, as to those injections which from their subtilty leave the point more doubtful. Besides, as we found in the former chapter, such changes are produced upon animal bodies by death, that membranes, which during life had been so tense as to prevent transudation, after death were so much altered, that in the gall-bladder, for example, they allowed the viscid bile to pass.

\* For example, Dr. Hales's injection of tallow, resin and turpentine varnish; which being injected, a part of the vermilion got into the bowels, although no greater force was used than that with which the blood circulates in the living body: but then it is probable that the vessels are weaker in the dead than in the living animal.



Does it not therefore become doubtful, when an anatomist injects a cavity from a vein, whether (although he cause no rupture) he may not separate the fibres already relaxed by death, in such a manner as to imitate this transfusion? And if one anatomist has been misled when he concluded transfusion took place in the living body, because he found it in the dead body, so may they likewise, who have concluded veins arose from cavities in the living because they had been able to push injections into such cavities in the dead body. It must, therefore, I think, be allowed that such experiments are at the best equivocal.

Another argument used in favour of veins arising from cavities, particularly from the intestines, is that some anatomists have affirmed that they have seen white chyle in the blood taken  
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from the mesenteric veins. But this argument will appear very inconclusive, when the reader recollects, that the *serum* of the blood let out from the veins of the arm is sometimes white, which must arise from some other cause than these veins absorbing chyle. And, therefore, if that appearance in the brachial veins, can be otherwise accounted for, than by absorption, we are left in doubt whether in those instances, where anatomists observed such a fluid in the veins of the mesentery, it had been owing, not to those veins absorbing it, but to their receiving it from the arteries. All the *serum* of the body being now and then as white as milk\*.

A third argument produced in support of absorption by the common

\* Instances of which may be seen in the first Part of these Exp. Inquiries.

veins,

veins is taken from the structure of the *penis*, whose veins arise from its cells; which cells, however, are now allowed to be particular organizations, and very different from those of the cellular membrane, and the blood is believed not to be absorbed, but to be impelled from these cells into those veins; and the argument is now given up even by some of those who were once the most strenuous in its favour\*—It need not therefore be here dwelt upon.

Ligatures, or compression on the large veins, have been considered as furnishing a fourth argument in favour of these veins arising from cavities, and doing the office of absorption. Thus the swelling of the legs in pregnant women, and in cases where tu-

\* See Professor Monro's State of Facts.



mors have been seen near the veins, has been explained from the *uterus* in the one case, and the tumors in the other, occasioning such compression, as to prevent the return of the venous blood. But there are two circumstances which make this argument far from being satisfactory. — First, the lymphatic vessels run near such veins, and it is doubtful whether the lymph may not be retained in the limbs more by the compression of these vessels, than by that of the veins. Secondly, The compression of a vein, may, by stopping the return of the blood, not only distend the small veins, but the small arteries, and the exhalants may be so dilated, or so stimulated, as to secrete more fluid than they did naturally. In this way, perhaps, the ligature which Dr. *Lower* made on the *cava inferior* of a dog occasioned the *ascites*\*.

\* De corde, cap. 2, p. 122.

An experiment which I have repeated, but my subject did not live so long as his, for mine died in half an hour, and had only a very little water in the *abdomen*.

*Lower* has related another experiment which has frequently been quoted by writers on the dropfy; that is, where he tied the jugular veins of a dog, and the dog's head became dropfical. Now were this an experiment which always succeeded it would be more decisive, for when the whole *cava* was tied, no part of the blood being able to return, all the vessels below, not only the small veins, but the small arteries, must have been extremely distended. Whereas in this experiment no such thing would take place, because the jugular veins so frequently communicate with other vessels, that there would still be a regress allowed to the blood: If the neck therefore became œdemitous, it would appear more likely



ly to have been occasioned by the ligature on the veins. But what shews that there must have been some fallacy in *Lower's* experiment, is, that these veins have since been frequently tied without an *œdema* being produced, or any signs of extravasated lymph. Thus, in not one of the experiments which I made on these veins in living dogs (as related in the first part of these Experimental Inquiries) was this effect ever produced: And Baron *Van Swieten* tied up both the jugular veins, and though he kept the dog four days afterwards, did not observe him any way incommoded\*. In one dog I even cut out both the external jugulars, and kept him near a twelvemonth without observing the least symptom of dropfy. I should therefore suppose, that in *Low-*

\* Comment in Boer. Aph. § 170, p. 266.



er's experiment, not only the veins, but the lymphatic vessels which lie near them had been tied; in which case the lymphatics would burst and occasion these symptoms. But in my experiment I took care to separate the vein from the lymphatics.

These arguments, therefore, in favour of absorption being performed by the common veins, which are brought from experiments where ligatures were made on large vessels, seem likewise to be liable to fallacy.

A fifth argument is taken from the structure of the *placenta*, where it has been concluded there are no lymphatics; and yet there must be absorption, and not a communication of the vessels; neither of which arguments are deci-

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five. For, there may be lymphatics in the *placenta*, though not yet discovered. Or there may be small vessels passing from the mother to the *fœtus*, though not yet injected.

A sixth argument is furnished by the experiments of some authors, in which experiments it is affirmed, that fluids injected into the intestines were soon afterwards discovered in their mesenteric veins. The experiment related by the ingenious *Kauw Boerhaave*, has been the most depended upon in this matter\*. In which experiment, water was injected into the intestines, and those intestines being compressed, the water was afterwards observed to run from the veins; but that some fallacy had crept into this experiment is now probable, from

\* See de Perspir, § 469, 470, 471.



its having been repeated several times in a very satisfactory manner\*, without being attended with the like success. The learned *M. de Haller*, indeed, in comparing these arguments, says, that in such cases where authority seems to ballance authority, he chuses rather to adopt the opinions of those who affirm, than of those who deny the fact. For, as he observes, this experiment may easily fail of success; but if it has ever succeeded, we shall not easily find another way of accounting for it, except by allowing that these veins open into the intestines†. But with due deference to the opinion of this excellent author, *Kauw Boerhaave's* experiment is not so conclusive as those alluded to above; for in his, the dog was

\* Dr. Hunter's Medical Comm. Ch. v.

† Elem. Phys. L. 24, S. 2, § vi.



opened immediately after death, and water being injected into his stomach, that water was seen first to dilute the blood, then to wash it from the *vena portarum*, and the experiment was continued a considerable time by means of pressing the stomach, which pressure furnishes a strong presumption that the water did not get into the veins by absorption but by a laceration, especially as the experiment continued to succeed for some hours after death; whereas absorption always ceases long within the first hour\*. This argument, therefore, which has been considered as so strong in favour of absorption by the common veins, is liable to objections.

\* *K. Boerhaave's* words (after mentioning that the blood was washed out by the wound made in the auricle of the heart) are as follow: “ Tandem  
 “ pura aqua tædioso labore *per horas*, lenissime  
 “ immittere aquam & premere ventriculum con-  
 “ tinuavi donec pallerent omnia vasa sanguine or-  
 “ bata per resorptam aquam”—See *de Perspir.* §470.

And

And lastly, A seventh argument used in favour of common veins absorbing, was, that many animals were destitute of any other vessels which could do that office. This was supposed to be the case with birds, fish, and amphibious animals; all of which some anatomists did not hesitate to affirm must want every part of the lymphatic system, and with great appearance of reason; since in the smallest quadruped they could easily find either lacteals or lymphatic glands upon the mesentery, but in the largest bird, or fish, neither lacteal vessel, nor conglobate gland could be seen. And if these animals (said they) be without the lymphatic system, absorption in them must be performed by other vessels, viz. the common veins; and if in them the common veins can do the office of absorption, why should not they like-



wife perform it in the human body, where such veins equally exist\*? But this argument is overthrown by the lymphatic system being now discovered in all these animals.

Such are the arguments produced in favour of the common veins doing the office of absorption, a doctrine which has lately been espoused by that excellent anatomist, Dr. *Meckel*, to whose observations, though agreeing with some already mentioned, it may be necessary to pay a particular attention.

Dr. *Meckel*'s conclusions in favour of this doctrine, are made entirely from injections in dead bodies. For, having filled the common veins by injecting

\* See Prof. *Monro*'s *Obs. Anat. Phys.* p. 57 — Dr. *Haller*'s *Elem. Phys. L.* 24, Sect. 2, § 3, p. 66 and 67.



mercury into the lymphatic glands, into the excretory ducts of the breasts, into the *vesicula seminalis*, into the hepatic ducts, and into the urinary bladder; he concludes, that the veins open into these parts in the living body to absorb from them\*.—A conclusion which is already proved to be liable to considerable objections, as we never can be sure whether our injection, in getting from these cavities into such veins, had gone by a natural, or by a forced passage. Dr. *Meckel* does indeed mention, that there were no marks of an extravasation in his experiments — Perhaps it might have been too small for observation. Nay, we have even reason to believe, that as the small vessels of the human body are very close to one another, our injection may sometimes burst from one into

\* See his *Nova Experimenta & Observationes*, Berol. 1772.

another lying in contact with it, without distending the cellular membrane which lies between them. A circumstance which I have seen happen even on the mesentery of a turtle, where upon injecting the lacteals I have more than once made the mercury pass into the common veins; but in all these cases, on a careful examination, I found it was by rupture, as could readily be distinguished in this animal, whose mesentery is extremely thin and transparent. And that it actually was so, and not by a natural passage, must be evident to every anatomist, who considers that this is an experiment which does not always succeed on the mesentery of the turtle, where, if there were natural passages, or if the lacteals opened into the veins, the mercury would probably run with great facility.

And



And the very same circumstance which Dr. *Meckel* has observed of a lymphatic gland, has happened to me some times on injecting these glands in diseased cases ; that is, I have filled the common veins, and in some instances, where I looked for it, I could distinguish the extravasation very readily, and therefore concluded, that in the other cases where the veins were filled, that it was also by an extravasation, though a more obscure one. I should thence suspect, that in Dr. *Meckel's* experiment, where he filled the common veins by injecting into the lymphatic vessels of a diseased gland, a similar deception had taken place ; especially as the force applied was considerable, he having used a column of mercury eighteen inches high.

And the supposition of the red veins opening into a lymphatic gland, appears improbable from an observation concerning the structure of the glands,  
for



for which we are indebted to Dr. *Mec-  
kel* himself, viz. that they are made  
of a convoluted lymphatic vessel\*. Now  
to suppose a lymphatic, which is a ves-  
sel given to absorb, should itself, even  
when convoluted, have a common vein  
opening into it for absorption from  
its cavity, is not, I think, consistent with  
what we know of nature's operations,  
who to repeat the words of *Glisson*,  
“*Operam suam non ludit, neque quod*  
“*actum est, agit denuo.*”

Similar objections might be made to  
the other experiments related by this  
very ingenious author; but enough  
I think has been said to shew how  
cautious we should be in making  
conclusions, with respect to the pas-  
sages of the living body, from ex-

\* *Epist. ad Hallerum.*

periments made on the dead, where from the weakness of the vessels, and other circumstances, we are so liable to be deceived\*.

Thus, on taking a review of the doctrine, that the common veins are the instruments of absorption, that doctrine appears to have no other support than respect for the authority of our predecessors, for all the arguments in its favour

\* Dr. *Hunter* and Dr. *Monro* found in their experiments, that injections readily burst from the arteries into the lymphatic vessels, by the intervention of the cellular membrane; these experiments they at first considered (as Dr. *Meckel* does his) as proofs of their having filled the natural passages; but more careful observations seem to have now convinced the former of these gentlemen that such conclusions are fallacious, and he now thinks that the injection may have burst into the sides of the lymphatic vessel. See his *Medical Commentaries*, p. 57.

it

are liable to considerable objections. Let us next therefore enquire, whether some other part of the human body may not do that important office.





C H A P. X.

*On the Use of the Lymphatic System.*

**T**HIS system, in all animals, we have found, consists of a trunk or thoracic duct, and of two extremities, namely, the lacteals and the lymphatic vessels. The lacteals can be traced from the thoracic duct to the intestines, through coats of which they pass, and open into their cavities by patulous orifices, in order to absorb the chyle and to transmit it through the thoracic duct to the blood-vessels. That this is their use, has never been questioned, since the first discovery of those vessels,

sels, from its always admitting of easy demonstration, that is, by giving an animal milk, and then opening him a few hours after, in which case the same fluid that is seen in his intestines can likewise be seen to have got into his lacteals—a satisfactory proof of the lacteals beginning from the intestines.

After thus being convinced, that the use of one branch of the system is to absorb, we cannot at first sight but wonder, that any anatomist should have hesitated to attribute a similar office to the other. Nevertheless some anatomists have been led to ascribe to the lymphatics a very different use to what they found the lacteals perform; particularly since the time that *Nuck* first made his experiments, in which he thought he injected these lymphatic vessels from the arteries, and therefore concluded, that they had no other use than



than as correspondent veins to return the lymph from such arteries as were too small to admit the red blood, or the *serum*. And in this opinion anatomists were confirmed by the theories of *Leeuwenhoeck* and of *Boerhaave*, concerning the gradation in the series of the globules of our fluids, and of the sizes of the vessels destined to convey them; thence the idea of the lymphatic vessels being small veins continued from arteries became so general amongst physiologists.

But although this idea was so commonly received, yet there were some physiologists who reasoned better on the subject; and amongst the first of these was *Glisson*, who, in a book published the very year after that in which *Bartholin* wrote upon the lymphatics, attributes to those vessels the office of carrying back to  
the



the blood-vessels the lymph which had lubricated the cavities of the body\*.

M. *Noguez* likewise, in a chapter where he mentions the name of Dr. *Glisson*, speaks of the use of the lymphatics, as follows: “ Ils reportent la  
 “ lymphe dans les vaisseaux sanguins  
 “ ou dans les veins, il y en a dans toutes  
 “ les parties du corps, ils repompent  
 “ la matiere lymphatique qui s’évacuë  
 “ par les arteres, on peut les nommer  
 “ conduits absorbans;” and again in another place, he says, “ ils recoivent  
 “ la lymphe subtile qui se repand sur  
 “ la surface de toutes les parties, et  
 “ dans les differentes cavitez du corps,  
 “ ils la reportent au sang†.

*Hambergerus* also seems to have had this idea of their office, for he says,

\* de Hepate, Cap. XLV. edit. Lond. 1654.

† Anatomie de l’Homme, 2d Edit. Cap. viii.

“ ex omnis generis cavo, humidum li-  
“ quidum vehente, five sit arteria, five  
“ vas fecernens, vel excretorium, vel  
“ aliis usibus destinatum, vasa lym-  
“ phatica oriuntur\*.”

*Frederic Hoffman* has been still more explicit on this subject, and has expressed the doctrine of the lymphatics being absorbents very completely, in his *Medic. Ration. system*, lib. 1, sect. 2, cap. 3; where he says,

“ § 2. Duplex est origo vasorum  
“ lymphaticorum, quaedam ex ipsis  
“ arteriis prodeunt, alia ex porosa &  
“ cellulosa partium substantia nascun-  
“ tur.

“ § 4. Lymphatica, quæ ex partium  
“ substantia oriuntur, aquosi succi nu-  
“ tritii partem resorbent, ac revehunt  
“ ad cor.

\* *Physiol. Med.* § 469.



“ § 7. Revehunt vero omnia lymphatica ex universo corpore lympham suam ad capsulam lumbarem & chyloferum ductum, inquam se exonerant.

“ § 11. Ad facilitandum lymphæ regressum vasa hæc valvulis instructa sunt, & quidem sigmoideis, numerosioribus & angustioribus, quæ quidem lympham libere transmittunt, impediunt tamen quo minus regurgitet.”

This opinion of the lymphatics being a system of absorbents has been adopted and supported with additional arguments, first by Dr. *Hunter*, and afterwards by Dr. *Monro*, who, besides shewing the fallacy of the experiments brought in favour of the common veins doing the office of absorption, have advanced the following to prove that the lymphatics perform it.

First, Their great analogy with the lacteals, with which they agree in their  
coats,



coats, in their valves, in their manner of ramifying, in their passage through the lymphatic or conglobate glands, and in their termination in the thoracic duct, and, in short, in every circumstance with regard to their structure; and thence it is probable they also agree with them in their use. And as the lacteals are known to begin from the surface of the intestines, and to be the absorbents of these parts, the lymphatics may begin from the other cavities of the body, and may absorb the fluids which had lubricated those cavities.

Secondly, The passage of the venereal, variolous, and other poisons into the constitution; these poisons first making an ulcer, and then being absorbed along with the matter of the ulcer and infecting the whole body. That in such cases they are not absorbed by the common veins, but by

the lymphatics, appears from their inflaming these lymphatics in their course, and by their generally inflaming a conglobate gland before they enter the system; a strong argument in favour of their being taken up by the lymphatic vessels, which pass through these glands in their way to the thoracic duct\*.

These two are the principal arguments by which the doctrine of the lymphatics being a system of absorbents has been supported. Experiments made by injections in the dead body, where such injections have been forced from the arteries into the cellular membrane, and from the cellular membrane into the lymphatics, have been likewise brought in favour of this doctrine, but improperly, and being

\* See Dr. Hunter's Medical Commentaries, See also Dr. Monro, de Vasis Lymph Valv.

now given up by those who advanced them\*, they need not be dwelt upon here.

But our experiments related above, furnish another argument in favour of the lymphatics being a system of absorbents; for, in chapter the seventh we have mentioned, that in these experiments we have always found the fluids contained in the different cavities of the body, and that contained in the lymphatics exactly agreeing with one another, in their transparency, in their consistence, &c. And in animals in health, we likewise found, when the one jellied on being exposed to the air, the other did so too; and in the animal reduced by low diet where the properties of the one were altered, those of the other were so likewise, and exactly in the same manner. So that

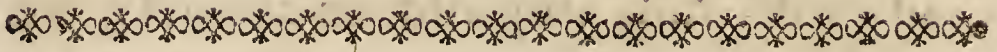
\* See Dr. Hunter's Medical Commentaries, p. 57.



we now seem to have obtained as decisive an argument in favour of absorption by lymphatics, as we before had of that by the lacteals; for the lacteals were concluded absorbents from their being found to run from the intestines filled with a fluid similar to what was in the cavity of the gut; so we seem here to have the same reason for believing that the lymphatics absorb from cavities, because they are found to contain a fluid exactly similar to what is observed in these cavities; a strong argument that the fluid had passed from such cavities into these lymphatics by absorption.

Such then seems to be the purpose for which the lymphatic vessels were provided, that is, to do the office of absorption, an office of the greatest importance to the animal; no wonder therefore, that there should be a system  
set

set apart for performing it, and not only in man and quadrupeds, but also in birds, fish, amphibious animals, and perhaps even in insects of the most perfect kind.



## C H A P. XI.

*An Examination of the Opinion, whether some of the Lymphatic Vessels may not be continuations of the small Arteries.*

I HAVE already observed, that soon after the discovery of the lymphatic vessels, *Glisson* and others suspected that they arose from the cavities of the body to take up the fluids exhaled from the blood-vessels; but; at the same time another opinion was entertained by some anatomists, namely, that a part of the lymphatics were reflected from the small arteries to which they corresponded, in the same manner

as



as the common veins belong to the arteries carrying red blood.

In this opinion, that the lymphatics were only veins, anatomists were confirmed from experiments made by injections; particularly the blowing air into the arteries of the kidney, spleen, &c. and seeing it return by the lymphatics\*; a fact that has since been proved to be owing to the air having burst from the arteries into the cellular membrane, and so having got into these vessels, and therefore by no means proving a direct communication between those arteries and the lymphatics†.

Other injections, likewise, such as mercury, water, &c. having been thrown into arteries, and afterwards having got into the lymphatics, have been men-

\* Nuck, *Adenog.* cap. 4, and 6.

† See Professor Monro de *Venis lymph* Valvulis  
tioned

tioned as so many proofs of a direct communication : but greater experience with injections has convinced some of the more accurate amongst later anatomists, of there likewise being a fallacy in these experiments ; or of the fluids having got from the arteries into the lymphatics, not by passages which were natural to the living body, but by such as were the effects of laceration in the dead one. The present Professor *Monro* has distinguished himself in this subject : from his observations† and those of Dr. *Hunter*\*, the notion of the lymphatics being continued from arteries seems to be very fairly exploded. And it is made probable, that the injections in dead bodies had mis-led their predecessors, who had not been sufficiently aware, that these injections might possibly have passed, not by natural, but by forced passages.

† de Ven. Lymph. valv.

\* Medical Commentaries.





C H A P. XII.

*On the structure of the Villi of the Intestines, and the manner in which Absorption is performed.*

THE term *Villi*, applied to the very small processes of the internal coat of the intestines, conveys an improper idea of their figure in the human body. In many quadrupeds indeed they are cylindrical, or like hairs or wool\*; but in the human subject they are broad and flat; and when viewed with a microscope they look like the *valvulæ conniventes* in minia-

\* I have seen them of that shape in the dog, cat, lion, and the ass.

ture,



ture, or are small folds of the internal coat : So the accurate *Lieberkühn* has painted them†.

The whole surface of the alimentary canal is covered with these processes ; but in the large intestines they are so very short, that to the naked eye the surface of these intestines appears smooth ; thence the learned *Albinus* has considered them as having no *villi*\*, which is true in one sense only, viz. that their inner coat does not appear shaggy, but spongy or cellular ; yet the partitions between these cells are similar in structure to the *villi* of the small intestines.

The appearance of the villous coat is very different in different parts of the alimentary canal,

In the *œsophagus* the *villi* are small and not so full of vessels, and are of the cylindrical or conical shape.

† de Villis Intestin. Tab. i.

\* Anotat. Academic, Lib. vi. Cap. viii.

At the upper part of the stomach the villous coat appears in a microscope like a honey-comb; or like the *reticulum*, or second stomach of a ruminant quadruped, in miniature; that is, full of small cells, which have thin membranous partitions. Towards the *pylorus* these partitions are lengthened so as to approach to the shape of the *villi* of the *jejunum*.

The *villi* of the *jejunum* are thin folds considerably broader than they are long, and when not injected they are very flat, so as to resemble *valvulae conniventes* in miniature, but are so small that they can but just be distinguished by the naked eye.

In the *ileon* the *villi* become rather longer in proportion to their breadth. In the *colon* and *rectum* the villous coat



coat is like the upper part of the stomach, honey-combed or cellular. These facts are only evident after a minute injection ; for in the uninjected state the *villi* collapse, so that their figure cannot be distinguished. The partitions between the cells of the internal coat of the *colon*, and of the stomach, being each very vascular, and agreeing with the *villi* of the *jejunum* in every circumstance except magnitude, are to be considered as having the same use, namely, to absorb, as will appear probable hereafter.

Upon each of the *villi* is an artery and a vein which make a net-work of branches, as is well expressed in the ingenious *Lieberkuhn's* plate\*.

Besides arteries and veins, it is probable that the *villi* have nerves distributed to them.

\* de Villis Intestinorum, Tab. 1, Icon. 2.

They



They likewise have lacteals, which, according to *Lieberkühn*, open on the extremities of the villi, sometimes by one and sometimes by more orifices.

Each villus, the same author thinks, has an *ampulula*, into which these orifices lead, and from the other side of the *ampulula* the lacteal passes through the coats of the intestines. This is the only circumstance, concerning these parts, in which I should differ from this very accurate observer, whose experiments, in support of his opinion about this *ampulula*, seem to be liable to fallacy. Of this I was first persuaded from observations made on fish, birds, and amphibious animals, in all

† An account of some preparations exhibiting these facts, was printed in the *Phil. Trans.* Vol. 59.

of

of which I can demonstrate, that the *villi* have a net-work of lacteals as well as a net-work of arteries and veins.

That the *villi*, in some fish, have a net-work of lacteals, I have distinctly seen in the turbot, where I have injected the lacteals with mercury, which readily runs from those vessels into the *villi*, and makes them turgid and erected. In the same way, I have likewise seen a net-work of lacteals on the *villi* of a turtle, where these *villi* are of a different shape, and, in some parts of the gut are cellular, or honey-combed, something like the lower part of the human stomach, only the partitions of the cells are here much larger.

In birds the experiment is more difficult, because their lacteals are full of valves, and their *villi* are small, compared

pared to those of the turbot, nevertheless I have succeeded in getting the valves to give way, so as to fill a few of their lacteals distinctly enough to be seen to divide into branches upon the *villi*, and therefore to prove that they do not form a bag or *ampulula*\*.

Since therefore a net-work of lacteals is found upon the *villi* of all these animals, from analogy we should suspect the same in the human subject, whose *villi* are of the same shape, that is, broad and flat, which figure would appear not a proper one for an *ampulula*.

The experiments from which the ingenious *Lieberkühn* was persuaded there was an *ampulula*, were; First, The *villi* appearing turgid with milk which had curdled in them, in such subjects as

\* See Philos. Transactions, Vol. 59, p. 213.



had taken milk just before their death\*. But whoever has made experiments with injections must be convinced of its being difficult to distinguish clusters of small vessels from bags, when these vessels are not filled with fluids of a brighter colour than milk or chyle; and even in those cases where such vessels were filled with vermillion (which is so much more vivid and distinguishable) some anatomists have been misled; particularly concerning those *corpora globosa* in the kidney, which have been considered as bags or *cryptæ*. But I have repeatedly observed and have now by me some preparations which prove that these *corpora globosa* are not uniform bags, but convoluted arteries, which comes near to the idea that *Ruysch* had of them. Some ingenious anatomists have warmly espoused a contrary opinion, and have not only supposed the kidney to have

\* de Villis Intestinatorum. § 2, 3.

*follicles*, but most other glands of the body, particularly the breast or *mamma*, and the salivary glands. But that they likewise have been deceived by a cluster of small vessels will appear probable, when we consider that the *corpora globosa* in the kidney, which have by so many been pronounced bags or *follicles*, are only small vessels clustered together, or convoluted. And on making a variety of experiments on these other glands, I think it evident in what manner the deception has happened to those ingenious anatomists; namely, when the excretory ducts of the breast, for example, are injected with vermilion and painter's size, the small *acinæ* of which that gland consists, are made extremely red, and such a preparation being dried, the *acinæ* appear as large as pins heads, so that the breast has been suspected to have *follicles* of that magnitude; but on injecting the breast

with mercury, which is a brighter substance, and better contrasted to the dried fibres, I have distinguished, what in the other preparation might be mistaken for a bag, was here evidently no more than the extremity of the excretory duct, terminating in one of these *acinae*, and dividing into a number of branches so suddenly as to come near to *Ruyfch*'s description of the *penicilli* of arteries; but the small branches, into which this extremity of the duct divided, were so close to one another, that in the preparation where they were filled with size and vermillion, they could not be distinguished, but in that where they contained mercury, it evidently appeared, that in each *acina* of the magnitude of a pin's head, there were a considerable number of branches, but so small as not easily to be seen with the naked eye.

The



The ingenious *Lieberkuhn* has mentioned another experiment, from which he was not only persuaded that the lacteals formed an *ampulula* upon the *villi*, but that this *ampulula* was filled with a spongy substance. This experiment he made by inflating the *villi* by the arteries and the veins, and upon drying the intestine and cutting the *villi* across he observed them spongy\*. But this is an appearance which may be as well explained, from knowing that each *villus* contains a net-work of small arteries and veins which, being inflated, might occasion the *villi* to assume a spongy appearance.

Since then the experiments from which the *villi* of the human subject were supposed to contain an *ampulula* are so equivocal, and since the *villi* can be proved in the other classes of animals, viz. in birds, fish, and the *amphibia*,

\* de Vill. Intest. § 8.

to have net-works of lacteals as well as of arteries and veins, the probability is in favour of their having the same structure in the human subject. But the difference between us is inconsiderable, for it may be nearly the same thing whether there is a bag filled with a sponge, or a *plexus* of vessels.

I have some preparations by me, adapted to the microscope in *Lieberkuhn's* manner, in which I think I can clearly shew the orifices of the lacteals on the extremities of the *villi*, where there appears, as he has described, sometimes to be one, and sometimes more orifices\*. My preparations were made by injecting into both arteries and veins a thin size, or glue, coloured with vermilion; when this was not pushed to great minuteness the *villi* appeared exactly as *Lieberkuhn* has painted them, with

\* *de Villis Intest.* § 3.

a net-work of arteries and veins on each, and when examined with a microscope no orifices could be distinguished, but each *villus* appeared to have a smooth edge. Yet in some part of the *ileon* where the injection had run more minutely, the *villi* appeared erected, and instead of being broad and thin were more round and cylindrical, and the extremity seemed spongy and porous, whilst all the sides of the *villus* were perfectly smooth and uniform. And moreover as in these preparations the orifices only appeared when the *villi* were completely erected, I think this circumstance points out the use of the *villi*.

It might be here objected that these were only lacerations of the *villi*, but I am persuaded they were not, from having, on repeatedly examining them, observed the pores or orifices very distinct and empty ; whereas, were they



lacerations, I think, I should have seen the injection in them, as the *villi* were so much distended by it.

It has long been observed by physiologists, that absorption takes place only in living animals, and not in the dead; for if an intestine in a dead animal be filled with milk, none of that milk will get into the lacteals; but in the living animal, the milk will readily be absorbed. This I think may be explained from what is above observed of the orifices of the lacteals appearing to open when the *villi* are erected, something like which may take place in the living animal; that is, whenever absorption is to be performed, the blood-vessels of the *villi* may become turgid, and the orifices of the lacteals may then stand rigidly open, and be capable of attracting, like capillary tubes made of hard substances. But in the dead body the *villi* being emptied

emptied of blood, the coats of the lacteals, being soft, collapse, by which means their orifices are closed, and they are thence made incapable of attracting the chyle, or of absorbing.

It is observable, that those parts of the skin which are intended to have more sensibility than the rest, have those processes called *villi* most remarkably; this is evident, when after a minute injection we compare the tips of the fingers, the lips, the *glans penis*,] with other parts of the skin; and this is still more observable in the tongue whose *papillæ* are the instruments of taste. In these instances some physiologists have suspected that the blood-vessels were some way subservient to the nerves for sensation, an opinion which I think is very probable; and the use of the *villi* of the skin, agreeably to their opinion, seems to be as organizations  
of

of vessels to become more turgid at particular times, by which turgescency the extremities of the nerves are made more capable of doing their functions ; and agreeably to this idea it is observable that when we attempt to taste any thing extremely grateful, the *papillæ* of the tongue can be seen to become erected\*.

\* The *papillæ* of the tongue in the human subject appear to the naked eye, when they are not minutely injected, quite smooth, but on a minute injection each of these *papillæ* appears covered with small vascular processes or *villi* ; so that in such a tongue every one of the *papillæ* seems in the microscope like a bunch of fibres, or rather like a sheaf of corn—Some preparations of which, adapted to the microscope, I have now by me. The learned Albinus seems not only to have observed this, but to have had the same idea of the use of these processes which he calls tubercles, and has painted them like those little eminences that appear upon a nipple, but I find them much longer. See his Annot. Acad. Lib. 1, cap. xv.

And



And as those *villi* of the skin seem to be organizations capable of that turgescency which is necessary to adapt the sentient extremities of the nerves to receive impressions, so I suppose the *villi* of the intestinal tube are able to exert a similar erection or turgescency, in order to make the small absorbents stand rigidly open, and thereby act like capillary tubes of glass or other hard substances: And perhaps such membranes as the *pleura*, *peritonæum*, &c. may be without *villi*, because such processes would be less proper for affording the smoothness of surface required for the motion of one *viscus* upon another: but to answer the same purpose they may have a network of blood-vessels surrounding the absorbing pores, which reticulation, by its turgescency, may make the pores stand rigidly open as those we have observed upon the *villi*. But this being a less perfect organization,

tion, and used here, merely because the more perfect, or villous, would be incompatible with the motion of the *viscera* upon those membranes, may, for that reason, be more liable to fail in doing its office, and thereby occasion dropsies of those parts; nothing like which seems to happen to the *villi*, which do not, as far as we know, ever fail in absorbing chyle so as to occasion a disease.

The orifices of the lacteals and lymphatics, therefore, by acting as capillary tubes, in consequence of a particular organization near their beginnings, are capable of absorbing the chyle and lymph; and as a capillary tube of glass being put into a basin of water will attract the water to a considerable height above the surface of that fluid; so the animal tubes or absorbents, merely by their attractive power, may not only imbibe but convey the fluid

fluid at least as far as the first pair of valves, whose distance from the orifice of the absorbents is probably very small. But whether the force of attraction extends much farther than the first pair of valves, may be a question. Some have suspected that these fluids were propelled forwards principally by this attraction, but it is not necessary to admit such a supposition, in order to explain the motion of the chyle, or of the lymph, because the vessels which convey these fluids are believed to have muscular fibres, which being stimulated by the fluid may contract peristaltically, and press the fluid forwards from one pair of valves to another.

The lymphatic system is very full of these valves, much more so than the venous, and the reason of this difference seems to be, that the blood in  
the



the venous system is strongly pressed forwards by the *vis a tergo* from the action of the heart and arteries, and therefore its course is less liable to be interrupted by any accidental pressure. But the motion of the absorbed fluid in these vessels having no such force, but only that of the attraction at the orifice, and the peristaltic contraction of the coats, might easily be overcome by any lateral compression, were it not for the valves, which seem to be given to prevent the retrocession of the lymph being considerable, and to make any lateral pressure, instead of preventing, rather promote its passage to the heart: and as the lymphatic vessels in the human subject not only accompany the arteries, but in many places pass under them, when the course over them is as direct, it would seem probable, as some physiologists have

have suggested, that this was done in order that they may have the pulsation of such arteries communicated to them, which pulsation, inconsiderable as it is, may rather promote the passage of the lymph.



## C H A P. XIII.

*Containing some Pathological Observations relating to the Lymphatic System.*

THE fluids which lubricate the different cavities of the body are sometimes collected in these cavities in an extraordinary quantity, and form dropsies, such as the *ascites*, *anasarca*, dropy of the *pericardium*, *thorax*, *tunica vaginalis*, &c.

In a former chapter we observed, when speaking of the lymph that moistens such cavities, that its properties  
vary



vary in different circumstances, and that in these dropfies the fluid that is let out by tapping is generally as thin as water, which instead of coagulating, when exposed to heat, only becomes a little turbid. Sometimes indeed it agrees with the serum of the blood in coagulating by heat, and sometimes it flows from these cavities in a viscid or ropey state. In all these cases the fluid occasioning the dropfy is different from the fluid that naturally moistens those cavities, which, in experiments related above, was found to agree with the coagulable lymph of the blood, in the circumstance of jelling merely by exposition to the air\*.

These circumstances being considered, I think we may thence be led to a more correct notion about the causes

\* The water in the ventricles of the brain should, I believe, be excepted, as I never saw it jelly, even when exposed to heat.

of those dropfies, which causes have been supposed to be either an increased secretion, or an impeded absorption, or a rupture of the lymphatic vessel; none of which probably, strictly speaking, gave rise to such morbid collections of water. For if merely an increased secretion, or an impeded absorption was the cause of an *ascites*, or an *anasarca*, then the fluid let out should resemble that contained in these cavities in living animals. The same reasoning holds good against these dropfies being occasioned by the rupture of a lymphatic vessel; that is, the fluid evacuated is not similar to what we found contained in those vessels in our experiments, where the lymph jellied on exposition to the air.

And as we observed in those experiments, that these fluids approached nearer to the nature of those found in dropfies,

dropfies, in proportion as the animal was weakened, or reduced, as particularly in the dog fed eight days on bread and water ; is it not therefore more probable, that in these kinds of dropfies there is something more than an increased secretion, or an impeded absorption ? that is, there is a perversion of the secretion, or the vessels throw out a fluid different from the natural one : which may happen, either from the exhalant arteries being themselves altered by disease, so as to change the properties of the fluid which passes through them ; or from the mass of blood being vitiated or abounding so much with water as to affect this secretion ; thence these dropfies are not primary diseases, but the consequences of others ; and a diseased liver, spleen or lungs, which so often accompany these dropfies, are not so properly to be considered as giving rise to them



by causing a rupture of a lymphatic vessel, or obstructing the course of the lymph, as by affecting chylication and sanguification; for when the liver, for example, is diseased, and the bile deficient in quality or in quantity, the food not being properly assimilated, may make a bad blood, which may affect the vessels, and may let go its water into these cavities.

But altho' from these considerations it seems probable, that an obstruction or rupture of the lymphatics is not the cause of these dropfies, where a mere water is found in those cavities, yet they may occasionally be the causes of others. If a lymphatic should burst in a person in health, a dropfy may ensue; but the fluid would possess the properties which that lymph does naturally, and be either found coagulated, or would be capable of coagulation, when let out: the same may be observed of an increased secretion, or of an obstruction

struction of a lymphatic vessel; the fluid would differ from mere water, and would either coagulate or be viscid. Instances of such fluids sometimes occur in dropfies.

Thus a viscid ropey fluid has been let out of the abdomen, not only in the dropfy of the *ovarium*, in which such a fluid is commonly met with, but likewise sometimes in the *ascites* in men.

In like manner, the cellular membrane is sometimes filled with a gelatinous fluid, which does not ooze out when the integuments are scarified, nor does it retain the impresson on being pressed with the finger, as in the common *anasarca*: this was remarkable in a woman that was in *St. George's Hospital* a few years ago, and who at the same time had an obstruction of her menses but no other symptom of ill health. The legs

in this woman were swelled to twice their ordinary size, but did not pit on being pressed with the finger. A case of the same sort may now be seen in one of the nurses at *St. Bartholomew's Hospital*.

A similar gelatinous fluid, is sometimes seen upon cutting into tumours of the rheumatic kind near the ligaments of the joints; and Dr. *Lower* observed, that it was common to find the *pericardium* filled with a jelly in dead bullocks.

As we have remarked of a rupture of the lymphatic vessels in an animal in health, that the fluid which escapes will coagulate; so we may observe of a wound of such a vessel, the lymph which oozes from it, if the person be in health, will not be a mere water, but will be like the coagulable lymph of the blood, in jelling on exposition  
to



to the air, only a little later than the blood itself does, if we may judge from what is observed in Chap. 7. A case of this sort I saw in a butcher, who by letting his knife fall upon his shin, cut some of the large lymphatic vessels which pass over the *tibia*, as represented at (cc) *Plate 1st*. From this wound there flowed a considerable quantity of a clear lymph, which, being confined by the dressings, jellied, and then, at first sight, appeared like a whitish *fungus*, but being loose could be removed with a *spatula*. Some cases of wounds of lymphatics are related by the late Professor *Monro*\*, who describes a white *fungus* as apt to arise from them; and since seeing the case above mentioned, I cannot help suspecting, that notwithstanding the accuracy of that gentleman, he had met with a deception of this sort. My

\* *Med. Essays*, Vol V. Art. xxvii.

patient, like his, was cured by tight pressure, and lint dipped in a solution of vitriol.

When a blister is applied to a person not much weakened by disease, as for example, behind the ear for the tooth-ach, or to one who labours under a violent fever or an inflammation, we find on removing the cuticle, a serous fluid discharged. This fluid, I have found, coagulates by heat, exactly like the serum of the blood, or the white of an egg. After this serous fluid is let out from the blistered part, we sometimes see over the inflamed skin, a white crust or jelly, which is easily removed, and seems to be the coagulable lymph of the blood, which has been thrown out by the inflamed exhalant arteries, and had jellied amidst the serum. When this jelly is more condensed,

densed, it appears not much unlike a second cuticle\*.

It is a fact universally admitted by physiologists, that all parts of the human body are bibulous, or imbibe fluids applied to them; thus garlick applied to the skin is soon smelt in the breath; and turpentine rubbed upon any part of the body soon gives to the urine a violet-like smell. In like manner, poisonous substances are sometimes taken into the constitution. The variolous matter, inserted under the skin by the point of a lancet, produces the small-pox; and the venereal matter, introduced by a chancre, occasions the *lues venerea*. These facts have been long known, but it is still a question by what channels these substances enter the body, whether by the common veins, which have most generally

\* In dropical cases the fluids discharged by blisters are more watery.

been



been suspected to absorb, or by the lymphatic vessels.

How little probability there is of the common veins doing this office, has been observed above; but there are many circumstances which prove that the lymphatic vessels perform it; and there are some appearances in diseases which cannot otherwise be well accounted for.

For example; after the insertion of the variolous matter under the skin of the arm, in inoculation, before that matter enters the constitution so far as to produce any fever or eruption, the lymphatic glands in the *axilla* most frequently swell, or inflame; a strong presumption, that it is through the channel of the lymphatic system that this poison enters the constitution.

After

After the application of the venereal matter to the genitals, where the skin is abraded, before the *lues venerea* is occasioned, there is commonly an inflammation of the inguinal glands, which circumstance renders it probable, that in this case too the poison enters by the lymphatic vessels.

On the application of blisters, we sometimes find lymphatic glands swelling between the part inflamed by the blister and the heart\*. Thus the axillary glands sometimes become painful from a blister between the shoulders; and I once from this cause saw glands swell where they are not commonly met with on dissection. It was in the case of my ingenious friend, Mr. H. Apothecary, who having applied a blister to his back, observed some small swellings opposite to the

\* See Professor Monro de Ven. Lym. Valv. p. 93.



inferior *costa scapulæ*, he shewed them to me, and I told him they were glands inflamed in consequence of an absorption of a part of the cantharides, and would subside on drying up the blister, which accordingly happened.

It may be worth remarking, that these cases of glands swelling in consequence of the application of blisters, furnish the strongest arguments in favour of the lymphatics being the instruments of absorption; because where a blister is applied, the skin is only inflamed and not eroded, so that if the acrid matter gets into the lymphatic system, it can only be by absorption. Whereas when the variolous matter is inserted with a lancet, or the venereal matter enters from a chancre, we might question whether it got into the lymphatics by absorption or by an erosion of the side of those vessels. But when the lymphatic



phatic glands swell in consequence of a blister, it seems decisive in favour of the poison entering the lymphatic system, merely in consequence of that system being endowed with a power of imbibing whatever is applied to the surfaces of the body.

Poisons which enter the constitution, besides being discovered by their affecting the lymphatic glands, can sometimes be traced by their effects on the lymphatic vessels. A case of this sort in consequence of the bite of a gnat, was lately observed by my ingenious friend, Dr. *Maddocks*, Physician to the London Hospital. This patient, as Dr. *Maddocks* informs me, had been weeding in a garden, and had been bit near the root of her thumb, where a painful tumour appeared. Soon after which one of the axillary glands inflamed and swelled, and from the tumour of her thumb to the  
*axilla,*

*axilla*, the ascent of the matter could be traced by a painful ridge or cord, which went on the fore part of the *cutubitus*, and inside of the arm, exactly in the situation of the lymphatic vessels painted in *Plate vi*, (g, h), one of which it seemed to be, inflamed in consequence of the absorption of the poisonous matter.

I have likewise lately seen the gland just above the inner condyle of the *os humeri*, as is represented *Plate vi*, (d) swelled in consequence of a wound and suppuration on the back of the middle finger.

In ulcers of the legs, the matter is sometimes absorbed and carried up the lymphatics, 'till it arrives at the glands in the groin, where it occasions a *bubo*; which *bubo*, as has already been observed, \* differs from the venereal one in

\* See above, p. 24.

being

being at the lower part of the groin, viz. in the glands, *f, f*, *Plate I.*

I have even seen the matter of an issue in the leg produce such a bubo by absorption, and in this case too the matter could be traced by a painful line in the inside of the thigh in the course of the lymphatic vessels, as represented in the same plate.

Matter formed in the joints, on being absorbed, likewise produces such buboes\*

And milk which has stagnated in the breast creates a painful swelling in the axillary glands.

The axillary glands are likewise frequently observed to swell in conse-

\* See Dr. Hunter's Medical Commentaries.



quence of cancers in the breast\*; and it is found to be of no use to extirpate the breast itself, unless the infected glands can likewise be removed; for otherwise the cancerous humour left in the glands may renew the disease: and indeed when these glands are affected in consequence of a cancer, the operation of extirpation must be very precarious, as we can never be certain that the matter which has got so far as these glands may not also have got a little further, and have entered the constitution.

In cancers of the lips, the lymphatic glands under the angle of the lower jaw, and on the side of the neck, are apt to swell from the same cause, viz. the absorption of the cancerous matter. And the like swellings may be produced by the absorption of the venereal *virus*

\* *Monro de Ven. Lymph Valv.* p. 92.

from

from sores in the lips. I have seen these glands swell in consequence of gum-boils, which frequently appear on the upper jaw, from the fang of a rotten tooth making its way thro' the jaw, and producing a suppuration that sometimes bursts outwards, sometimes into the socket of the tooth, and sometimes disappears without rupture; in which case I have several times seen the glands under the angle of the lower jaw swell and become painful, during the few days that the boil was diminishing.

In short, wherever there is an erosion or ulceration of the body attended with acrid matter, that matter is apt to be absorbed, and in passing into the constitution commonly inflames the lymphatic glands which lie between the part eroded and the thoracic duct; a fact well deserving the attention of the

P                      surgeon,

surgeon, who might otherwise take these glandular tumours for primary diseases, and might expect to cure them without attending to the ulcers themselves, but in vain; for being occasioned by the absorption of acrid matter, they will remain so long as the matter continues to be absorbed: but that matter being once removed, these glandular tumours will generally subside of course.

And moreover, as it frequently happens that these poisons are not immediately absorbed, but remain for some time in the wound before they enter the vascular system, it gives us an opportunity of preventing the disease by cutting out the morbid flesh, and thereby extirpating the poison before absorption has taken place; a practice that has been used successfully for the bite of a mad dog, and cannot be too strongly recommended, as it seems to be



be the only certain way of preventing the ill consequences of such an injury. In those cases where the knife cannot be used, the application of the actual or potential cauteries has been recommended; for these cauteries, by destroying the poisonous matter, and the parts which it has already tainted, may preserve the constitution from the infection. It is also probable, that the venereal poison might be prevented from entering the constitution, if immediately upon the appearance of a chancre the patient would submit to the excision of that chancre, or to have a caustic applied to it. In like manner, since it is known that when the cancerous matter is once generated, whether in the *mamma*, *testis*, or any other gland, that such matter, on being absorbed, will infect the other parts of the body; is it not

therefore a strong argument in favour of the early extirpation of cancers, that the longer they are suffered to remain, the more probability there will be of the cancerous humour being taken up by the absorbents, and spreading the infection?

As the lymphatic vessels pass thro' the lymphatic glands in their way to the thoracic duct, when these glands are obstructed, the lymph, not being able to get into that duct, is retained in the extremities; thence we so often see dropfies the consequences of diseased lymphatic glands; which dropfies cannot be cured till the obstruction of the gland be removed. But as I have already observed, the lymphatic vessels do not constantly pass through glands but some of them pass by their sides; thence it is possible that a gland may be perfectly obstructed,  
and

and yet the lymph may get by the collateral branch of a lymphatic into the thoracic duct, and not be retained in the extremity so as to occasion a dropfy or *œdema*. In like manner a gland may be perfectly eroded, or may be cut out, sometimes, without the lymph being thereby prevented getting into the thoracic duct. And it may also happen, that the venereal, or other poison, may, upon being absorbed, pass into the constitution by one of these lateral branches without entering a lymphatic gland or inflaming it. That this is probable the reader may believe, upon looking over the plates, particularly (*Plate III.*) where the mercury appears to have passed from the groin the whole length of the trunk without entering a lymphatic gland. From which fact may be understood, how the venereal poison sometimes enters the constitution, and produces

P 3



duces the *lues* without occasioning a *bubo*, an instance of which I saw lately. And the variolous matter introduced by inoculation, although frequently producing inflammation and swelling of the lymphatic glands, yet is not always attended with those symptoms; to which may be added, that another reason why these poisons do not constantly affect the lymphatic glands in their way into the body, may be the lessened sensibility of these glands in some particular cases: whence the same poison which at one time would have produced the worst effects, may at another pass through these glands without inflaming them.

And lastly, not only obstructed lymphatic glands sometimes occasion dropsies, but also whatever impedes the  
passage

passage of the lymph into the veins; whether it be a thickening of the coats of the jugular or subclavian veins near the termination of the thoracic duct, or a tumour of the aneurysmal, schirrhous, or encysted kind, contiguous to any part of the lymphatic system; for such tumour, by compressing the lymphatic vessels, may prevent the return of the lymph, and may thereby occasion a dropy or *œdema* of the parts from which these vessels originated.

Upon the whole, whoever carefully views the lymphatic system must be convinced, that as it explains, and points out the cure of many diseases, it deserves the attention of the practitioners of the healing art. And as it is so generally diffused through the animal kingdom, it strongly claims the regard of those who wish to inquire philosophically into the animal œcono-

my, especially, as by the knowledge of this system, we are now flattered with the hopes of ascertaining the use of the lymphatic glands, the thymus, and the spleen; which discoveries are to be the subjects of the third part of these inquiries.





## P L A T E I.

*Exhibits the more superficial Lymphatic  
Vessels of the lower Extremity.*

- A The spine of the *os illium*
- B The *os pubis*
- C The illiac artery
- D The knee
- E,E,F Branches of the crural artery
- G The *musculus gastrochnemius*
- H The *tibia*
- I The tendon of the *musculus tibialis  
anticus*.

*On the Out-lines.*

- a A lymphatic vessel belonging to the  
top of the foot
- b Its first division into branches

C,C,C

c,c,c Other divisions of the same lymphatic vessel.

d A small lymphatic gland

e The lymphatic vessels which lie between the skin and the muscles of the thigh.

f,f Two lymphatic glands at the upper part of the thigh below the groin.

g,g Other glands

h A lymphatic vessel which passes by the side of those glands without communicating with them; and, bending towards the inside of the groin at (i), opens into the lymphatic gland (k)

l,l Lymphatic glands in the groin, which are common to the lymphatic vessels of the genitals and those of the lower extremity.

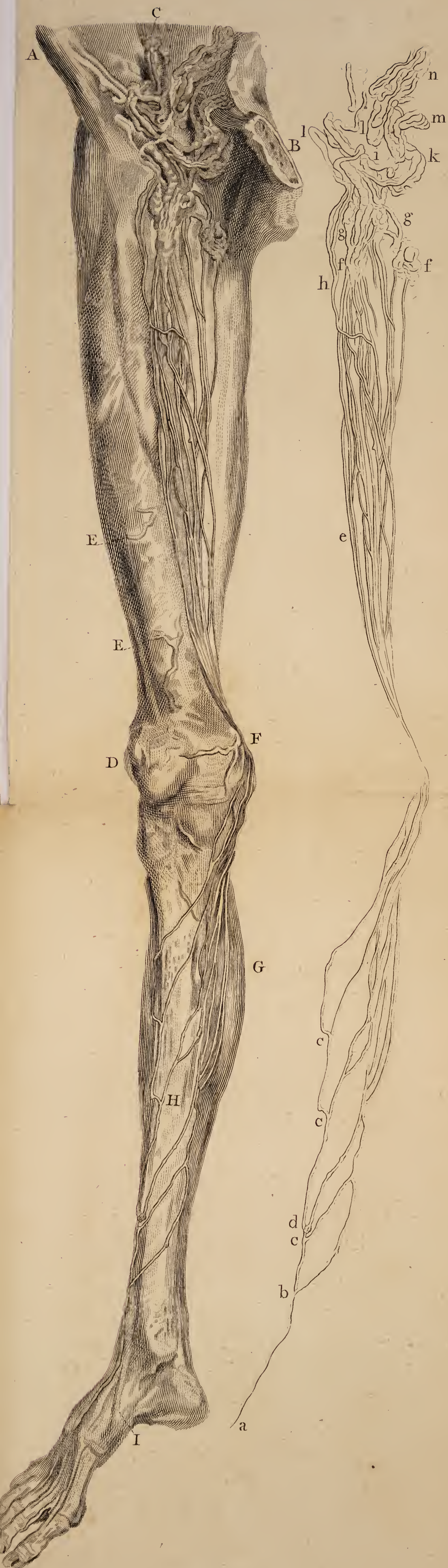
m,n

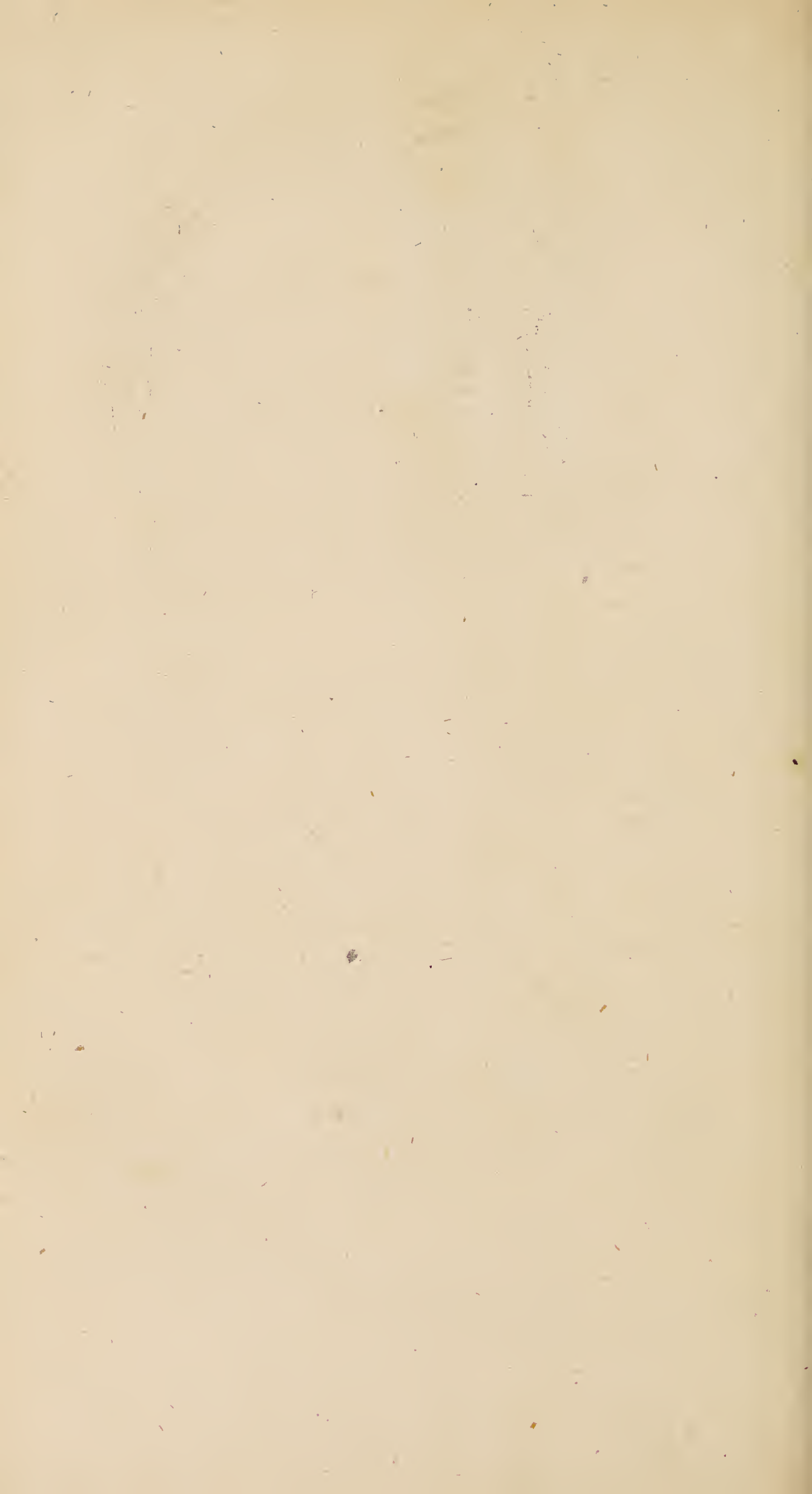


m,n A plexus of lymphatic vessels passing on the inside of the iliac artery.

N. B. The lymphatic vessels appear in these plates more regularly cylindrical than they are represented by *Nuck*, *Ruyfch* and others, in whose plates such vessels are painted more like chains of vesicles than I have ever seen them.











## P L A T E II.

*Exhibits a back View of the lower Extremity, dissected so as to shew the deeper seated Lymphatic Vessels which accompany the Arteries.*

N. B. This extremity was dried before the plate was made from it, and the muscles are therefore much shrunk.

A The *os pubis*

B The tuberosity of the *ischium*

C That part of the *os illium* which was articulated with the *os sacrum*

D The extremity of the illiac artery appearing above the groin

E The knee

F, F The two cut surfaces of the *triceps* muscle, which was divided to shew the









the lymphatic vessels that pass thro' its perforation along with the crural artery.

G The edge of the *musculus gracilis*

H The *gastrocnemius* and *soleus*, much shrunk by being dried, and by the *soleus* being separated from the *tibia* to expose the vessels.

I The heel

K The sole of the foot

L The superficial lymphatic vessels passing over the knee, to get to the thigh.

*On the Out-lines.*

M The posterior tibial artery

a A lymphatic vessel accompanying the posterior tibial artery

b The same vessel crossing the artery

c A small lymphatic gland, through which this deep seated lymphatic vessel passes.

d The

d    The lymphatic vessel passing under a small part of the *soleus* which is left attached to the bone, the rest being removed.

e    The lymphatic vessel crossing the popliteal artery

f,g,h Lymphatic glands in the ham, through which the lymphatic vessel passes.

i    The lymphatic vessel passing with the crural artery through the perforation of the *triceps* muscle.

k    The lymphatic vessel, after it has passed the perforation of the *triceps*, dividing into branches which embrace the artery (l).

m    A lymphatic gland belonging to the deep seated lymphatic vessel. At this place those vessels pass to the fore part of the groin, where they communicate



communicate with the superficial lymphatic vessels.

- n A part of the superficial lymphatic vessels appearing on the brim of the *pelvis*.



## P L A T E III.

*Exhibits the Trunk of the Human Subject, prepared to shew the Lymphatic Vessels and the Ductus Thoracicus.*

A The neck

B,B The two jugular veins

C The *vena cava* superior

D,D,D,D The subclavian veins

E The beginning of the *aorta* pulled to the left side by means of a ligature, in order to shew the thoracic duct behind it.

F The branches arising from the curvature of the *aorta*.

G,G The two carotid arteries

H,H The first ribs

I,I The *trachea*

K,K The spine

L,L The *vena azygos*

M,M The descending *aorta*

Q 2

N The



228 *Description of the Plates.*

- N The cœliac artery dividing into three branches.
- O The superior-mefenteric artery
- P The right *crus diaphragmatis*
- Q, Q The two kidneys
- R The right emulgent artery
- S, S The external illiac arteries
- g, d The *musculi psoæ*
- T The internal illiac artery
- U The cavity of the *pelvis*
- X, X The spine of the *os illium*
- Y, Y The groins
- a A lymphatic gland in the groin, into which lymphatic vessels from the lower extremity are seen to enter\*.
- b, b The lymphatic vessels of the lower extremities passing under pouparts ligament.
- c, c A plexus of the lymphatic vessels lying on each side of the *pelvis*.
- d The *psoas* muscle with lymphatic vessels lying upon its inside.

\* The letters are very small on this plate, that it might be less disfigured by them.

- c* A *plexus* of lymphatics, which having passed over the brim of the *pelvis* at (*c*), having entered the cavity of the *pelvis*, and received the lymphatic vessels belonging to the *viscera* contained in that cavity, next ascends, and passes behind the iliac artery to (*g*).
- f* Some lymphatic vessels of the left side passing over the upper part of the *os sacrum*, to meet those of the right side.
- g* The right *psoas*, with a large *plexus* of lymphatics lying on its inside.
- h, h* The *plexus* lying on each side of the spine.
- i, i, i* Spaces occupied by the lymphatic glands.
- k* The trunk of the lacteals lying on the under side of the superior mesenteric artery.
- l* The same dividing into two branches, one of which passes on each side

of the *aorta* ; that of the right side being seen to enter the thoracic duct at (*m*).

*m* The thoracic duct beginning from the large lymphatics.

*n* The duct passing under the lower part of the *crus diaphragmatis* and under the right emulgent artery.

*o* The thoracic duct penetrating the *thorax*.

*p* Some lymphatic vessels joining that duct in the thorax.

*q* The thoracic duct passing under the curvature of the *aorta* to get to the left subclavian vein. The *aorta* being drawn aside to shew the duct.

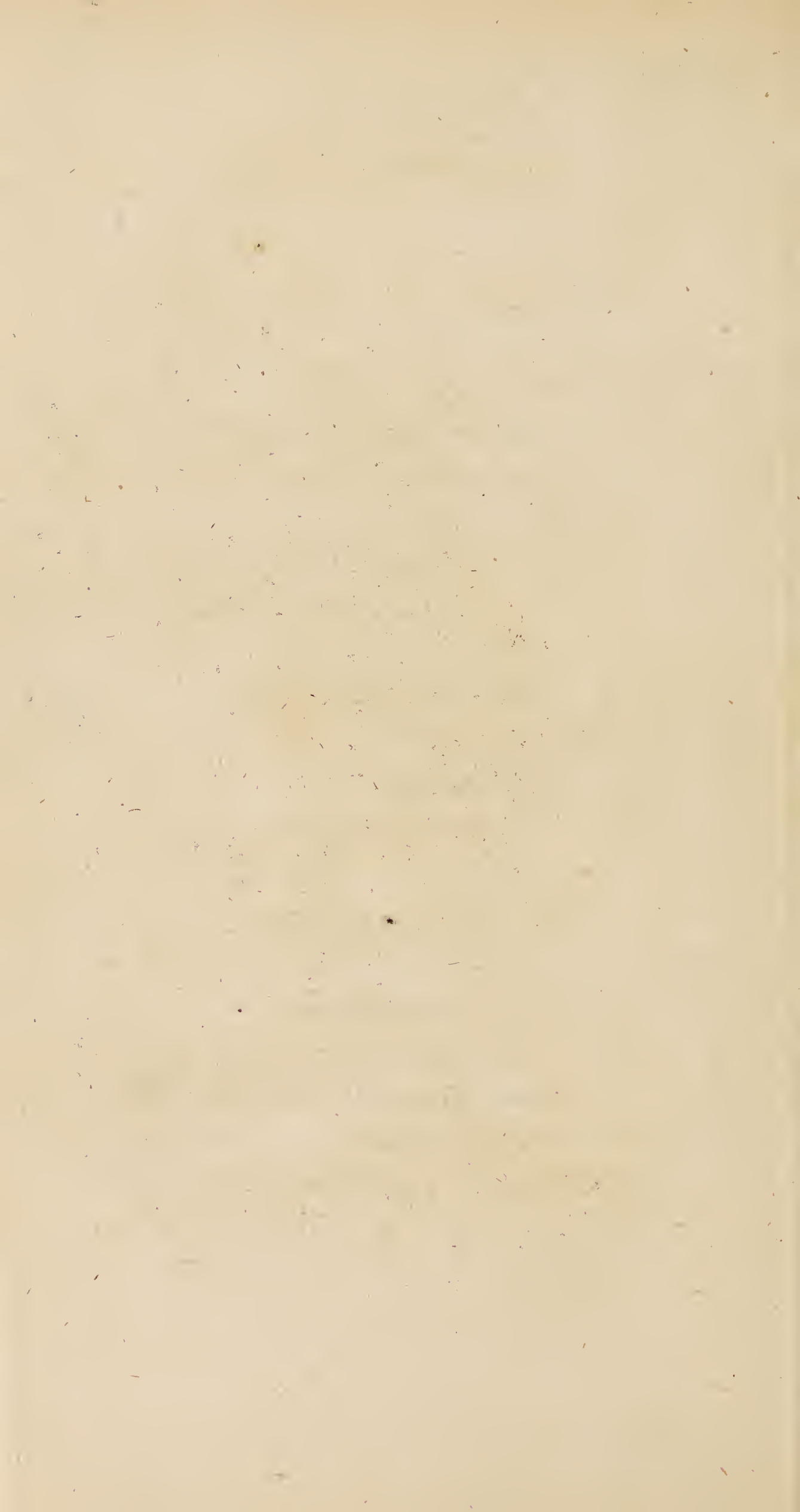
*r* A *plexus* of lymphatic vessels passing upon the *trachea* from the thyroide gland to the thoracic duct.

PLATE









P L A T E IV.

- A The neck  
B,B The two shoulders with the pectoral muscles turned over them  
C,C The arms  
D,D The cut ends of the clavicles  
E,E The extremities of the two first ribs  
F,F The subclavian muscles  
G,G The ribs  
H The *trachea*  
I The *aorta ascendens*

*On the Out-lines.*

- K The *aorta descendens*  
L The trunk of the carotid, and subclavian artery of the right side  
M The left carotid  
N,N The left subclavian artery

Q 4

O The ]



- O The *cava superior*
- P The trunks of the subclavian and jugular veins
- Q The right subclavian vein
- R The right jugular vein
- S The left subclavian vein
- T The left jugular
- a* The thoracic duct passing on the right side of the descending *aorta* (K), behind the ascending *aorta* (I), and behind the lower part of the left carotid artery (M), and then appearing at (*b*).
- b* The upper part of the thoracic duct lying between the left carotid and the left jugular vein, and passing behind that vein downwards and outwards towards the angle between the left jugular and the left subclavian.
- c* The extremity of the thoracic duct entering the angle between the left jugular and the left subclavian vein.

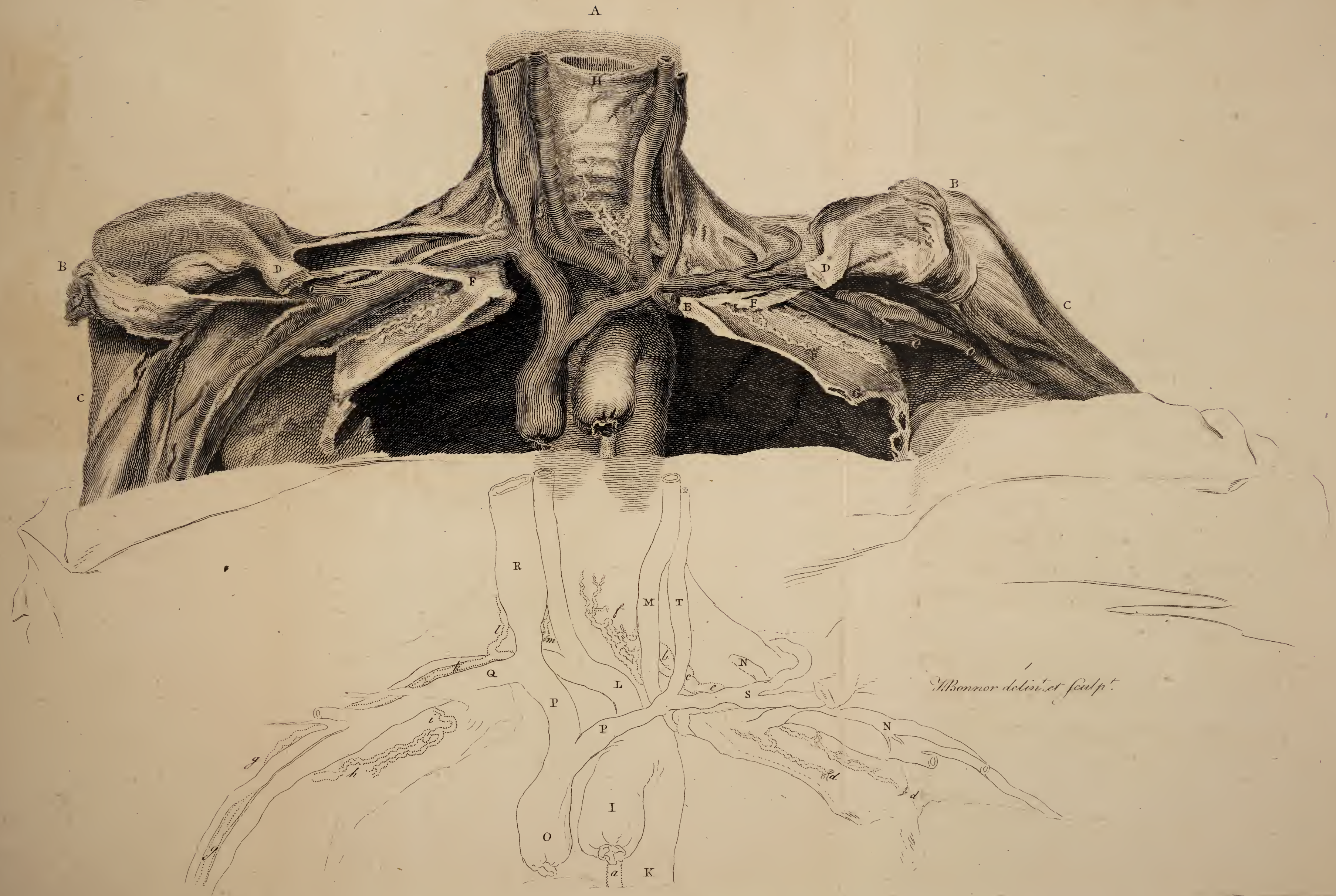
*d, d*

- d,d* Two of the trunks of the lymphatics of the left arm lying upon the outside of the chest, and passing under the subclavian muscle F, (*see the figure*) and the subclavian vein S, the clavicle itself being removed, and its cut extremity seen at D, upon the figure.
- e* A trunk formed by the lymphatics of the upper extremity, which trunk joins the extremity of the thoracic duct (*c*), and enters the angle between the left jugular and the left subclavian vein.
- f* Lymphatics from the thyroide gland running upon the *trachea*, and passing under the *aorta* to get to the thoracic duct, just where that duct enters the veins.
- g,g* A trunk of the lymphatics of the right arm lying on the outside of the right brachial artery.
- h* A branch of this trunk making a net-work on the outside of the *thorax* just under the clavicle.



- i* That network passing under the right subclavian vein (Q) and under the subclavian muscle F, (on the figure) the clavicle itself being removed.
- k* The common trunk both of that *plexus* and of all the other lymphatics of the upper extremity of the right side, which trunk lies between the right subclavian artery and vein, and passes into the angle between the right jugular and the right subclavian.
- l* The trunk of the lymphatics of the right side of the neck lying on the outside of the right jugular vein, and passing into the angle between that vein and the subclavian of the same side.
- m* One of the lymphatics of the right side of the thyroide gland going under the right jugular vein.









P L A T E V.

*Exhibits a back View of the fore Arm and Hand. The Preparation from which this View was taken having been previously dried, the Muscles appear very slender.*

- A The hand
- B The lower extremity of the *radius*
- C The lower extremity of the *ulna*
- D The muscles on the back of the fore arm turned aside to exhibit a deep seated lymphatic vessel, which perforates the interosseous ligament to get to the fore part.
- E The *olecranon*

*On the Out-Lines.*

a,a,a Lymphatics appearing on the back of the fore arm immediately under the skin.

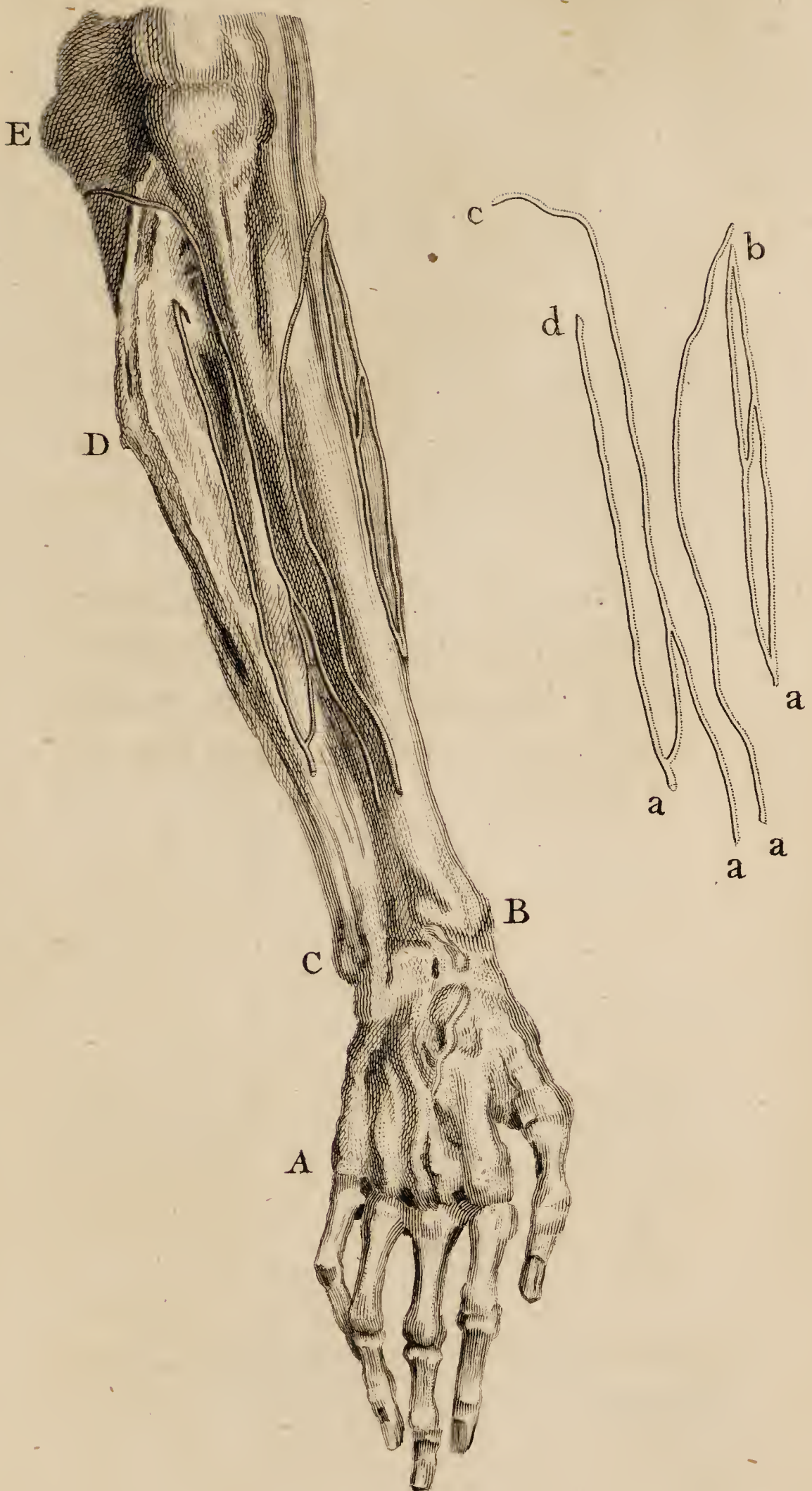
b Some



236. *Description of the Plates.*

- b Some of the lymphatics bending over the upper extremity of the *radius* to get to the fore part of the arm.
- c A lymphatic passing over the *ulna*, immediately under the *olecranon*, and under the inner condyle of the *os humeri*, to get to the fore part of the arm.
- d A lymphatic which has penetrated the muscles, perforates the interosseous ligament, and gets to the fore part of the arm near the radial artery.

Plate V.







P L A T E VI.

*Exhibits a fore View of the upper Extre-  
mity. This Plate was likewise made  
from a dried Preparation, and the  
Muscles therefore appear very small.  
It has a peculiarity in the ulnar Ar-  
tery running over the Muscles instead  
of under them.*

A The scapula

B The clavicle

C The extremity of the brachial ar-  
tery

D The muscles lying on the inside of  
the arm

E The inner condyle of the os humeri

F The lower extremity of the radius

*On the Out-Lines.*

a A lymphatic vessel which lies in  
the cellular membrane immediately  
under

under the skin, and passes up on the inside of the arm to the axillary glands.

b Superficial lymphatic vessels passing over the muscles from the back of the fore arm, and likewise over the *biceps* to the glands in the *axilla*.

c A superficial lymphatic from the back of the fore arm.

d A gland through which it passes.

e The lymphatics from the anterior and the posterior part of the fore arm uniting.

f, f Lymphatic glands in the *axilla*.

g A deeper seated lymphatic vessel lying close to the radial artery which it accompanies all the way to (h).

h The deep seated lymphatic vessel passing under the interosseous and ulnar arteries, and appearing again on the arm at (i).

i The







i The deep tested lymphatic vessel

lying close to the subclinal artery.

k Two small lymphatic glands this

which is pulled.

l The same vessel now becomes much

larger and passing under a branch

of the artery and some cellular

membranes, and appearing at (o).

m The trunk of the deep tested lymphatic

vessel passing upwards to the

axilla, where it enters the glands, n.

o Three axillary glands, which are

common both to the superficial and

the deep tested lymphatic vessels.





















